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GENERAL ELECTRIC COMPANY
REVIEW

Vol. VII SCHENECTADY, N. Y., MAY, 1906 No. 1

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HIGH VOLTAGE TRANSFORMERS OF LARGE CAPACITY

By W. S. Moody

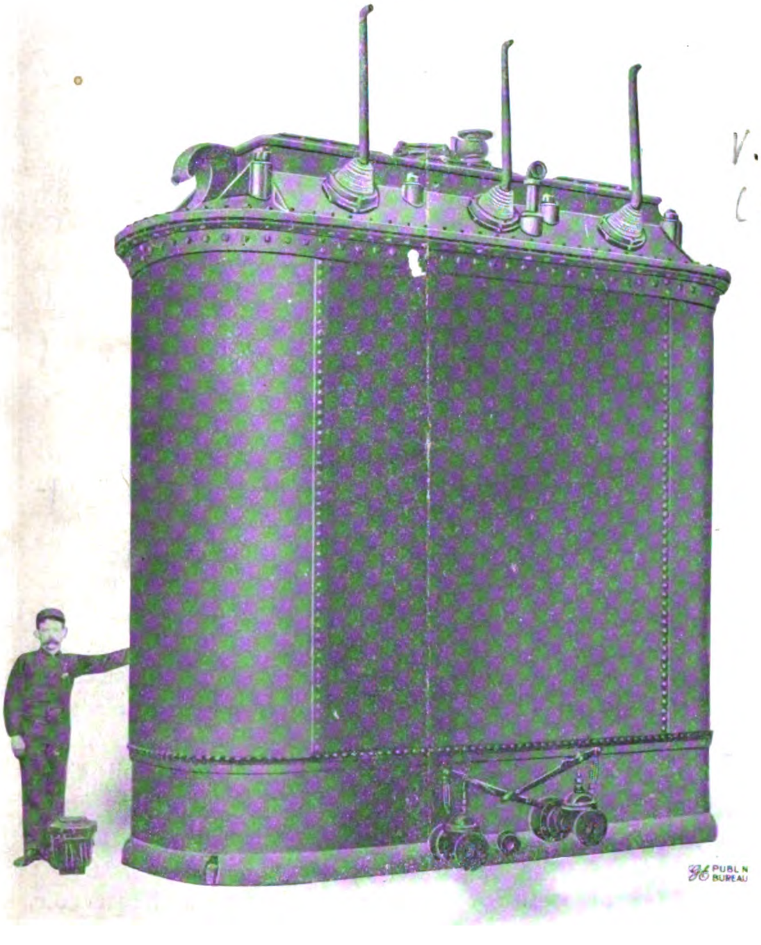

Fig. 1

FOT 25-7500-30,000/60,000 6600/13,200 Volt Transformer. The Transformer at the left is an **H 60-.6 1040/2080-52/104** Volt Unit.

Six of these Units, aggregating 45,000 kw., are to be installed for the Great Northern Power Co., of Duluth, Minn.

The growth in the size of generators, in recent years, for A.C. power transmission, has rendered desirable a corresponding increase in the kilowatt capacity and voltage of transformer units, for stepping up the generator voltage to the high tensions

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required for economical transmission over long lines, and for stepping down again at the receiving end.

This growth in capacity and voltage of transformer units has brought up many problems of insulation, cooling and structural design, the practical solution of which has produced, from the old self cooled transformer of the early days of A.C. engineering, the existing types of air blast, self cooled oil immersed, and water cooled oil immersed transformers.

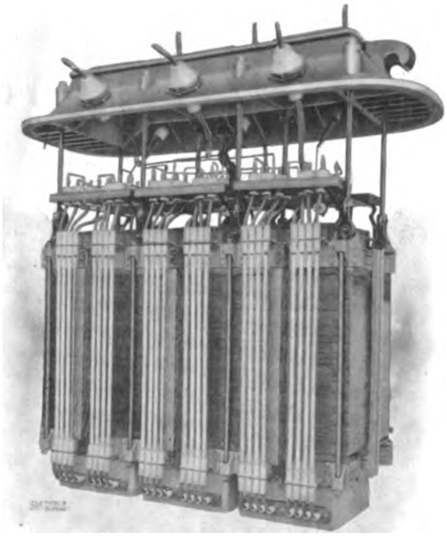


Fig. 2

FOT 25 7500 30,000/60,000 6600/13,200 Volt Transformer removed from its tank (Low Voltage Terminals in Front).

To facilitate a clear understanding of the engineering problems that have had to be solved in the design of large transformer units, a brief description will be given of two types built by the General Electric Co.: the oil immersed water cooled design (type WC) and the forced oil immersed, separately water cooled design (type FO) which is a logical development of the type WC.

The type WC transformer was developed in order to provide the necessary insulation and cooling for large high tension units without making the transformers as large as they would have had to be made if designed on the self cooled oil immersed plan. In the type WC transformer the oil is set into continuous circulation by the cooling effect of a water coil, placed in the top of the transformer tank, to which the oil transfers the heat generated in the transformer: the oil rising through ducts provided in the iron and copper structure of the transformer, giving up its heat to the water coil and descending between the transformer and the walls of the tank. The induced circulation of the oil, thus effected, secures high cooling efficiency of the oil in this transformer comparing favorably with the self cooled oil immersed type. The largest units of this type built by the General Electric Company up to the present date are the twelve 2670 kw., 10,000/12,000-50,000/60,000 volt, 25 cycle, single-phase transformers which are being installed at the transformer house of the Electrical Development Co. on the Canadian side of Niagara Falls.

The type FO transformers can be built of much larger capacities than the largest existing type WC transformers, without such increase in size as to necessitate shipment of the transformers in parts for erection at the place of installation. The forced oil design allows the natural circulation of the oil to be increased to any desired extent, thereby obtaining a rapid and positive circulation which greatly increases the cooling efficiency of the oil. The forced oil circulation is accomplished by taking the cooling coil out of the transformer tank, and effecting the cooling in an "external circuit" comprising an oil cooler, pump and reservoir, as shown in the accompanying schematic diagram, Fig. 3: thereby greatly reducing the size and weight of the transformer tank, the space required for oil between the transformer structure and the tank, and the amount of oil itself. The new design thus compares with the ordinary water cooled oil immersed transformer very much as the air blast type compares with the old self cooled transformers.

The use of a pump and reservoir in the oil circulating system gives much better control of the oil circulation in the transformer than in the type WC; so that the heating may readily be held within the limit of a 35° temperature rise for continuous full load operation. Moreover, this method of oil circulation ensures such uniform and positive cooling that much higher temperature rises may safely be permitted in transformers operated at moderate overloads. With ample capacity provided in oil and water circulating pumps, the transformer can safely be called upon to carry extreme overloads under emergency conditions.

The oil is circulated by pressure and the water by suction, so that any leak that may develop in the circulating system cannot result in the admission of water into the oil.

The largest type FO transformers that have been built are the six units for the Great Northern Power Co. designed for a nominal capacity of 7500 kw. at 25 cycles, three-phase, but actually capable of carrying 10,000 kw. continuously at a safe temperature rise. The high tension windings are adapted for 30,000 or 60,000 volts and the low tension windings for 6600 or 13,200 volts. Three of these transformers are to be installed in the main generating station, on the St. Louis River, the ultimate layout of which will call for eight units, to be supplied by eight 7500 kw. General Electric generators. The other three transformers will be installed in the Duluth sub-station, the ultimate layout of which will comprise four units.

One of these transformers is illustrated in the accompanying views, Figs. 1 and 2, showing, respectively, the high voltage and low voltage terminals. The capacity of each unit—nearly three times the capacity of the type WC transformers above referred to—represents by far the largest amount of power ever handled by a single transformer unit.

For the reasons set forth the new transformers are more economical in weight of active transformer material, tank and oil, and in space occupied, than they would be if they were designed with an internal water coil depended upon to induce a circulation in the cooling oil. At the same time, transformers of such very large capacity are necessarily much larger and heavier than any transformers that have been built up to present date. The Great Northern Co. transformers are 14 ft. 10 in. high, 14 ft. long and 5 ft. 10 in. wide, and certain structural details, which have not hitherto been taken into particular account, have therefore required special attention. For example, the supporting framework, by means of which the 130,000 lb. of active material in each of the new units is suspended, follows the principles of bridge design. The suspension construction adopted in the type WC, for convenience of installation and inspection, is retained: the transformer structure being supported, clear of the bottom of the tank, from the cast iron cover, so that cover and transformer may be lifted together from the tank.

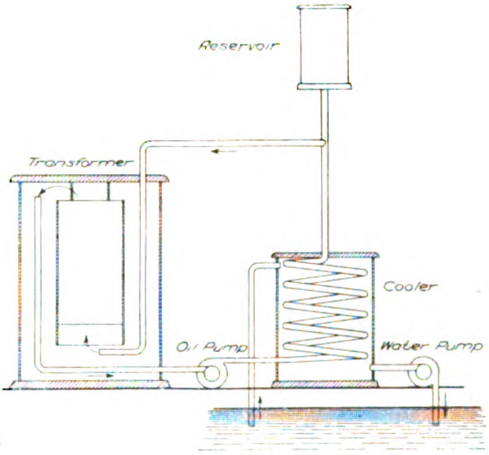


Fig. 3

Cooling System of Type FO Transformer

The reservoir serves to give a head for the oil circulating system. A common cooler is provided for a bank of transformers. Entrance of water into the oil, from any accidental leak that might develop in piping or joints, is prevented by placing the cooler on the pressure side of the oil pump and on the suction side of the water pump. In hydro-electric installations the cooling water is taken from and returned to the tail-race.

ELECTRIC HEATING DEVICES

The following orders have been received since the beginning of the fiscal year for General Electric Company electric heating devices:

Water Heaters, Chafing Dishes and Percolators	559
Stoves, Ovens, Grids, Etc.	591
Radiators	254
Cigar Lighters and Heating Pads	636
Flat Irons	24,000

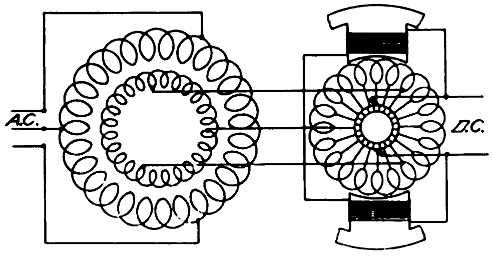
Of the above number of flat irons sold, an aggregate of 22,000 irons have been ordered for future delivery. These orders include one sale of 5000 irons, four sales of 1000 irons each and twelve sales of 500 irons each. The remaining 2000 irons are comprised in about one hundred and thirty orders.

THE MOTOR CONVERTER

By H. F. T. Erben

At present the most usual methods of converting alternating current to direct current are by the rotary converter and the motor generator set. Both of these machines give highly reliable service at frequencies not exceeding 60 cycles. Another piece of apparatus which is now being developed for this service is the motor converter, which has characteristics similar to both the rotary converter and motor generator.

The motor converter consists of two elements, an induction motor and a rotary converter, which are mechanically coupled by having a common shaft, and which are also electrically coupled by permanently connecting the rotor of the motor to the armature of the converter, as shown on the accompanying diagram of a three-phase, bipolar unit. By this arrangement the power is transmitted through the induction motor element of the machine, partly mechanically and partly electrically, to the converter element. Inasmuch as the motor and converter are connected in concatenation, the synchronous speed is divided, so to speak, between these two elements in the ratio of the number of poles of the converter element to the total number of poles of both A.C. and D.C. elements: giving an actual shaft speed corresponding to the synchronous speed for the sum of the number of poles on both machines, and therefore much lower than the speed of an ordinary rotary converter designed for the same frequency. For instance, if the two elements have an equal number of poles—six poles on the induction motor and six poles on the converter—the actual speed of the machine will be one-half of the synchronous speed of an ordinary six pole rotary converter supplied from the same A.C. line.



Connections of Motor Connecter

Since the direct current armature of the motor converter operates partly as a rotary converter armature and partly as the armature of a D.C. generator, the C^2R loss in the armature conductors and the field loss due to armature reaction will have values lying between the corresponding losses in a rotary converter and in a D.C. generator. The efficiencies will therefore be somewhat higher than for the generator of the same capacity in a motor generator set and lower than for a rotary converter.

The induction motor design permits the machine to be run direct on high tension—e.g., 13,200 volts—without step-down transformers, thereby effecting some saving in space and cost on the complete outfit. Moreover, the motor converter does not require any reactance for compounding, as there is enough reactance for this purpose in the induction motor. Another advantage resides in the fact that main slip rings are done away with, the A.C. rotor and D.C. armature being simply connected together along the shaft.

One of the most essential advantages of the motor converter for the higher frequencies is that a much lower frequency is impressed on the converter armature than is supplied from the line to the induction motor. This feature means a converter element with a comparatively small number of poles, and correspondingly small number of sets of brushes and low peripheral speed of commutator, resulting in low maintenance and good commutation characteristics. Since the dimensions of the induction motor element depend upon the primary frequency and not upon the speed of the rotor, considerable weight economy will be effected in motor converters, for the higher frequencies, as compared with the motor generator. The motor converter is started with great ease and convenience from the A.C. side by operating the A.C. element as a form L (internal resistance) motor, or as a form M (external resistance) motor.

A number of these machines are in commercial operation abroad,* and a 500 kw., 60 cycle experimental machine of this type is now under construction at the Schenectady Works.

RECENT IMPORTANT SALES

New York Office

ADAMS EXPRESS CO., NEW YORK, N. Y.

Thirty GE-1012 H 85 volt 40 amp. 1200 rev. per min. automobile motors.

Fifteen S-26 controllers.

Fifteen S-35 controllers, with resistances.

ALLEGHENY COUNTY LIGHT & POWER CO.,
ALLEGHENY, PA.

For Pittsburg, Pa.

Four H 60-100-10000/9500/9000-235 volt transformers.

Four IRT 4-11-60-235-25-250 volt hand operated automatic controlled regulators.

BRUNSWICK-BALKE-COLLENDER CO.,
LONG ISLAND CITY, N. Y.

Forty 440 volt form K induction motors ranging from 3 to 35 h. p. and aggregating 491 h. p.

BUFFALO GENERAL ELECTRIC CO.,
BUFFALO, N. Y.

One 400 kw. frequency changer set, consisting of an AQB 20-400-375 2200 volt 60 cycle generator direct connected to an ATB 8-425-(570 h. p.) 375-2200 volt 25 cycle three-phase synchronous motor.

Two 400 kw. frequency changer sets, consisting of an AQB 20-400-375 2200 volt 60 cycle two-phase generator direct connected to an ATB 8-425 (570 h. p.) 375-11000 volt 25 cycle three-phase synchronous motor.

CONSOLIDATED RY. CO., NEW HAVEN, CONN.

Five two-motor GE-57 equipments.

Twelve four-motor GE-80 equipments.

COPPER QUEEN CONSOLIDATED MINING CO.,
NEW YORK, N. Y.

For Morence, Ariz.

Three ATB 28-400-107-2300 volt generators.

ROBERT FRAZER, UTICA, N. Y.

Two ATB 28-105-257-220/125 volt DDO Y connected four-wire generators.

Two CE 4-5½-950-125 volt belted exciters.

Four switchboard panels.

HERKIMER COUNTY LIGHT & POWER CO.,
LITTLE FALLS, N. Y.

For Dolgeville, N. Y.

One AQB 22-1200-327-2300 volt water wheel driven generator.

One motor generator set, consisting of:

One CL-B 6-50-720-125 volt generator, and one IQ 10-75-720-2300 volt form L induction motor.

Three WC 60-5000-2200/2120/2040/1960-two-phase,-15000/20000/22000 three-phase transformers.

Switchboard.

HUDSON RIVER ELECTRIC POWER CO.,
GLENS FALLS, N. Y.

One ATB 20-2500-240-2000 volt generator.

One MP 4-22-12 kw. 700-125 volt exciter.

Three WC 40-1667-34700/60000 Y-2000/2500 volt transformers.

One switchboard complete with TA regulator.

For Saratoga, N. Y.

Two WC 40-350-30,000 Y/60,000 Y volt (two independent secondaries) transformers with dial switch.

Two WC 40-670-30000 Y/60000 Y volt (two independent secondaries) transformers with dial switch.

Two IRS 2-38-40-2300-173-220 volt motor operated induction regulator, with appurtenances.

INTERNATIONAL TRACTION CO.,
BUFFALO, N. Y.

Two HC 12-1000-250 25 cycle rotary converters with necessary transformers and accessories.

Four switchboard panels.

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*See, for instance, an article entitled "Recent Extensions at the Manchester Electricity Works" in the Electrician (London) March 30, 1906, page 956, referring to sub-station equipments consisting of three 500 kw., 6000 volt, three-phase, 600 volt direct current motor converters installed for use on 50 cycle lines.

Five four-motor GE-57 car equipments, with K-14 controller.

Additional K-14 controllers, and miscellaneous car equipment.

Long Island R. R. Co.,
Long Island, N. Y.

For Richmond, L. I.

Forty-two BD-2 and DS-2 220 volt induction motors ranging from 1 to 25 h. p. and aggregating 161 h. p.

Public Service Corporation, Newark, N. J.

Forty-seven four-motor GE-80 equipments complete for single end cars.

Seven four-motor GE-80 equipments for single end cars.

One hundred and fifty-two GE-80 motors.

Rochester Ry. Co., Rochester, N. Y.

Twenty-five four-motor GE-54 with K-28 controllers.

Thompson Starrett Co., New York, N. Y.

For U. S. Express Realty Co.

Four C 4-150-2000-125 volt Curtis steam turbine-generators.

Ticonderoga Pulp & Paper Co.,
Ticonderoga, N. Y.

One ATB 20-450-360-600 volt generator, with direct connected exciter.

Switchboard.

Witherbee Sherman Co.,
Mineville, N. Y.

For Port Henry Power Station.

One ATB 2-800-1500-6600 volt Curtis steam turbine-generator.

One C 2-25-3600-125 volt Curtis steam turbine-exciter.

One 25 kw. motor generator set.

Three AB 25-266-6600/6000-3300 volt transformers.

One HT 25-5-6600/3300-110 volt three-phase transformer.

One switchboard.

Boston Office

Caribou Water, Light & Power Co.,
Caribou, Me.

One ATB 20-200-600-2300 volt 60 cycle generator with direct connected exciter.

This plant has recently been changed from 125 cycles A.C. and 500 volts D.C. to an up-to-date 2300 volt, 60 cycle three-phase station.

Columbia Improvement Co., Boston, Mass.

One AQB 4-500-1800-2300 volt Curtis steam turbine-generator.

City of Holyoke, Mass.

One ATB 6-1000-1200-2300 volt Curtis steam-turbine.

Saco & Pettee Machine Shops,
Newton Upper Falls, Mass.

One ATB 48-360-150-600 volt engine driven generator.

One CL-B 6-22-725-125 volt exciter.

Switchboard.

Four I 8-50-900-550 volt form L induction motors.

One CQ 7½-7½-800-110 volt motor.

Three type H transformers, aggregating 50 kw.

Stone & Webster, Boston, Mass.

For Houston Electric Co., Houston, Tex.

Twenty four-motor GE-81 (30 h. p.) car equipments with K-12 controllers.

Chicago Office

Alton, Granite & St. Louis Traction Co.,
Alton, Ills.

Three GE-70 two-motor car equipments.

American Smelters Securities Co.,
New York, N. Y.

For Flat River, Mo.

Thirteen 440 volt form K induction motors ranging from 20 to 250 h. p. and aggregating 880 h. p.

Anaconda Copper Mining Co.,
Anaconda, Mont.

Two ATB 16-550-450-440 volt generators.

Three WC 60-400-23000/2200 volt transformers.

Switchboard.

Billings Water Power Co.,
Billings, Mont.

One ATB 48-360-150-2300 volt water wheel driven generator.

Central Illinois Construction Co.,
Peoria, Ills.

For the 80-mile single-phase interurban road of the Southern Illinois Traction Co.

Ten four-motor GEA-605(75 h. p.) equipments, with Sprague-General Electric type M A.C.-D.C. control.

Ten A.C.-D.C. straight air brake equipments.

Eight H 25-200-33000-3300 volt step-down transformers, and switchboard apparatus, for four complete single-phase sub-stations.

Eighty-three miles of catenary line material.

The following D.C. apparatus was also ordered:

Six four-motor GE-73 equipments with Sprague-General Electric type M control.

Four TC 6-300-500-600 volt 25 cycle rotary converters, with accessories.

Switchboard for four rotary converter sub-stations.

The following apparatus will be installed in the customer's Peoria power plant:

One 75 kw. Curtis steam turbine-exciter.

One 70 kw. induction motor exciter set, consisting of:

One CL 6-70-500-125 volt exciter direct connected to a three-phase 25 cycle 2300 volt form K induction motor.

One HT 25-75-33000-2300 volt three-phase transformer.

Three WC 25-150-33000-370 volt single-phase water cooled transformers.

Two HC 10-750-300-600 volt 25 cycle rotary converters.

Chicago & Southern Traction Co.,
Chicago, Ills.

Ten four-motor GE-80 car equipments.

Ten straight air brake equipments.

CP-21 compressor.

Citizens Gas & Electric Co.,
Waterloo, Iowa

One ATB 4-500-1800-2300 volt Curtis steam turbine-generator.

Citizens' Ry. Co., Lincoln, Nebr.

Five two-motor GE-54 car equipments.

Commonwealth Electric Co.,
Chicago, Ills.

One 75 kw. Curtis steam turbine exciter.

Conrey Placer Mining Co., Ruby, Mont.

Three WC 60-200-46200/34700/23100-17350-2200/2400 volt transformers with panels and switches.

Consolidated Electric Light & Power Co.,
Kansas City, Mo.

One frequency changer set composed of an AQB 20-500-375-2300 volt 60 cycle generator driven by an ATB 8-530-375-6600 volt 25 cycle synchronous motor.

One three-unit Brush arc set composed of two 4 amp., No. 13-D, 15000 volt Brush arc generators driven by one 180 Kw., 6600 volt synchronous motor.

Two hundred fifty magnetite lamps to be operated from the Brush arc set.

Decatur Ry. & Light Co.,
Decatur, Ills.

One 300 kw. 300 rev. per min. frequency changing motor generator set.

East St. Louis & Suburban Ry. Co.,
East St. Louis, Ills.

One MP 14-1000-100-575 volt generator.

Fort Worth Light and Power Co.,
Fort Worth, Tex.

One AQB 72-1000-100-2300 volt generator with exciter.

Illinois Valley Ry. Co., La Salle, Ills.

One ATB 28-1000-107-370 volt 25 cycle generator.

One 25 kw. motor generator exciter.

One 400 kw. rotary converter 25 cycle.

Switchboard.

Three WC 25-300-15000/26000-370 volt transformers.

Kansas City Western Ry. Co.,
Kansas City, Mo.

Four four-motor GE-73 car equipments, with Sprague-General Electric type M control.

Muskogee Electric Traction Co.,
Muskogee, Ind.

Four GE-67 two-motor equipments.

North Shore Electric Co.,
Blue Island, Ills.

Two motor generator sets each consisting of an ATB 24-500-300-4000 volt 60 cycle generator driven by an ATB 10-530-300-9000 volt, 25 cycle synchronous motor.

Oklahoma Gas & Electric Co.,
Oklahoma City, Okla.

One ATB 72-1000-100-2300 volt generator.

Two Exciter sets each composed of one CL 6-40-720-125 volt generator and one I 10-60-720-2080 volt Induction motor.

One MP 6-50-400-125 volt marine set.

Ottumwa Ry. & Light Co., Ottumwa, Ia.

Five two-motor GE-54 car equipments.

St. Paul Gas Light Co., St. Paul, Minn.

One motor generator set consisting of one IQ 12-700-600-2300 volt and two MP 8-250-600-125 volt generators.

One 25 kw. Curtis steam turbine-exciter.

Shawnee & Tecumseh Ry. Co.,
Shawnee, Okla.

Three four-motor GE-80 car equipments.

Eight two-motor GE-80 car equipments.

Southern Michigan Ry. Co.,
South Bend, Ind.

Six four-motor GE-74 car equipments with Sprague-General Electric type M control.

Tri City Ry. Co., Davenport, Ia.

Five straight air brake equipments.

Yegen Bros., Billings, Mont.

One ATB 32-600-225-2300 volt generator.

One MP 6-35-300-125 volt exciter.

Switchboard.

Philadelphia Office

American Railways Co., Philadelphia, Pa.

Twenty-two two-motor GE-80 car equipments.

Twenty GE-80 motors.

Thirty-seven four-motor GE-80 equipments.

Six CP-22 straight air brake equipments, for double end operation.

One AQB 8-1500-900-2300 volt Curtis steam turbine-generator.

Beacon Light Co., Chester, Pa.

One AQB 8-1500-900-2300 volt Curtis steam turbine-generator.

Wm. Cramp & Sons Ship & Engine Building Co.,
Philadelphia, Pa.

Six MP 6-15-400-110 volt standard marine generating sets, with three sets of spare parts.

Juniata Hydro-Electric Co.,
Philadelphia, Pa.

For Warrior Ridge, Pa.

Four ATB 36-500-200-2300 volt water wheel driven generators.

Two CL-B 6-75-550-125 volt exciters for direct connection to water wheels.

Two ATB 4-500-1800-2300 volt two-stage Curtis steam turbine-generators.

Seven WC 60 cycle, 500 kw. 2300-11000/45000 volt transformers.

Switchboard.

Lynchburg Traction & Light Co.,
Lynchburg, Va.

One ATB 4-500-1800-2300 volt, Curtis steam turbine-generator.

One C 2-20-4500-125 volt Curtis steam turbine-exciter, non-condensing.

Two switchboard panels.

Niles-Bement-Pond Co., Philadelphia, Pa.

Eighty-four CO crane motors.

Norfolk & Southern R. R. Co.,
Norfolk, Va.

One ATB 32-1000-94-13000 volt generator.

One switchboard panel.

One MP 6-50-400-125 volt marine exciter set.

One HC 6-500-500-600 volt 25 cycle rotary converter, with necessary transformers and appliances.

Six switchboard panels.

Pennsylvania Steel Co., Philadelphia, Pa.

Three MP 10-300-150-250 volt generators.

Three LS 201 surface locomotives.

Philadelphia Electric Co., Philadelphia, Pa.

Six AQB 14-150-514-5500 volt synchronous motors.

Philadelphia Rapid Transit Co., Philadelphia, Pa.

Four hundred GE-80 motors, replacing obsolete motors of competitive make.

Philadelphia & West Chester Traction Co., Philadelphia, Pa.

For Llanerch, Pa.

One C 4-400-1800-575 volt Curtis steam turbine-generators.

Potomac Electric Power Co., Washington, D. C.

One ATB 4-5000-750-6600 volt Curtis steam turbine generator. This is the first of several turbines which will be installed in the new power station to be located on the east branch of the Potomac north of the Bennings Race Track.

Scranton Electric Construction Co., Scranton, Pa.

For Pennsylvania Coal Co., Old Forge Colliery, Pa.

Three LM-101 M 1-28 in. gauge cable reel locomotives, with cable.

Southern Power Co., Charlotte, N. C.

For Old Point, N. C.

Three WC 60-1000-11,000-22,000-22,000-44,000 volt step-up transformers

Three WC 60-2000-22,000-44,000-11,000-22,000 volt step-down transformers.

Three switchboard panels.

United States Cast Iron Pipe & Foundry Co., New York, N. Y.

For Burlington, N. J.

One C 4-150-2000-250 volt Curtis steam turbine-generator.

Sale made by the New York office.

West Jersey & Seashore R. R. Co., Philadelphia, Pa.

For Atlantic City Division.

Ten two-motor GE-69 car equipments complete, with Sprague-General Electric type M control. This is an additional order to the large sale reported in the G. E. Review, January, 1906, p. 40.

San Francisco Office

Astoria Electric Co., Astoria, Ore.

Two 50-light 2300 volt constant current transformers, and panels, with 80 lamps, cutouts.

Balakalala Consolidated Copper Co., Kennett, Cal.

One I 12-175-600-2080 volt form L induction motor, with panel.

Boston Machine Shop Co., Oroville, Cal.

Nine induction motors, aggregating 387 h. p.

Eleven type H transformers, aggregating 390 kw.

Bowers Rubber Works, San Francisco, Cal.

Six induction motors, aggregating 415 h. p.

California Gas & Electric Co., San Francisco, Cal.

Three IRT regulators.

Sixty current transformers.

Twelve type K-2 oil switches.

Twenty-four type K-3 oil switches.

Columbia Improvement Co., Boston, Mass.

One CL 6-40-720-125 volt generator.

One MP 6-75-270-125 volt generator.

One IQ 6-10-60-720-2300 volt induction motor.

Department of the Interior, United States Geological Survey, Washington, D. C.

For reclamation work at Roosevelt, Ariz.

Three ATB 6 900-500-2300 volt vertical shaft generators.

Two CL-B 6-100-700-125 volt vertical shaft generators.

Switchboard.

East Shore Suburban Ry. Co., Richmond, Cal.

Three four-motor GE-67 equipments with K-28 controllers.

Edison Electric Co., Los Angeles, Cal.

Fifty-eight hundred type I induction meters, and 850 constant current transformers.

One hundred and thirty-two type H transformers in capacities from 7½ to 20 kw. and aggregating 1658 kw.

International Steam Pump Co., New York, N. Y.

One I 10-75-720 form K induction motor.

Three type H transformers, aggregating 150 kw.

Los Angeles Gas & Electric Co., Los Angeles, Cal.

One ATB 8-1500-900-2300 volt 60 cycle Curtis steam turbine generator.

Milton City Government, Milton, Ore.

One ATB 8-100-900-2300 volt generator, with switchboard and transformers.

Chas. C. Moore & Co., San Francisco, Cal.

For Pacific Gas & Electric Co., San Francisco, Cal.

Three ATB 60-5000-100-18000 volt generators.

One ATB 40-300-150-480 volt generator.

One ATB 30-150-200-480 volt generator.

Four MP 6-75-270-250 volt generators.

Three 100 Kw. transformers.

Sixteen 440 volt induction motors, aggregating 382 h.p.

Ophir Gold Dredging Co., San Francisco, Cal.

Three type H transformers, aggregating 225 kw.

Oxnard Construction Co., New York, N. Y.

One I 12-125-600-2080 volt form K induction motor.

Pacific Coast Mfg. Co., Los Angeles, Cal.

One ATB 48-300-125-2300 volt generator.

Pacific Coast Oil Co., Richmond, Cal.

Two two-motor GE-60 equipments with K-10 controllers.

Pacific Portland Cement Co. Cement, Cal.

Twenty-eight induction motors aggregating 795 h. p.

Pacific States Telephone & Telegraph Co.,
San Francisco, Cal.

Twelve mercury arc rectifier outfits.

Portland General Electric Co.
Portland, Ore.

Five hundred and eighty-six type I induction meters.

Puget Electric Ry. Co., Tacoma, Wash.

One four-motor GE-90 equipment with K-14 controllers.

One four-motor GE-66 equipment with type M controller.

San Diego Electric Ry. Co.,
San Diego, Cal.

Three two-motor GE-67 equipments.

San Francisco Gas & Electric Co.,
San Francisco, Cal.

Six IRS regulators.

Four motor generator sets each consisting of an ATB 14-1060-514-11000 volt synchronous motor, direct connected to an MP 10-1000-514-275 volt D.C. generator.

Eight switchboard panels.

Forty-eight K-3 oil switches.

San Francisco, Oakland & San Jose Ry.,
Oakland, Cal.

Six two-motor GE-66 equipments.

Seattle Electric Co., Seattle, Wash.

Tweny-five four-motor GE-80 equipments.

One three-phase synchronous motor panel.

Seventy-five 16 in. AC fan motors.

Sixty 12 in. D.C. fan motors.

Union Gold Dredging Co.,
Centreville, Ida.

One AQB 10-450-360-500 volt generator with exciter and switchboard.

Twelve type H tranformers aggregating 910 kw.

There were also sold a number of small belt driven AC generators aggregating 220 kw., induction motors aggregating 438 h. p. and transformers aggregating 230 kw.

United R. R. of San Francisco,
San Francisco, Cal.

Three four-motor GE-58 equipments with K-12 controllers.

Washington Water Power Co.,
Spokane, Wash.

One three-unit motor generator set consisting of two MP 8-500-514-300 volt D.C. shunt wound generators driven by one ATB 14-1060-514-4000 volt synchronous motor.

Switchboard.

Seventeen transformers aggregating 62 kw.

Twelve hundred and fifty flat irons.

Cincinnati Office

Columbus Northern Ry., Power & Equipment
Co., Columbus, O.

One ATB 2-800-1500-2300 volt form T Curtis steam turbine-generator.

Two complete sub-station equipments, each consisting of one 300 kw., 600 volt 25 cycle, rotary converters, with transformers and necessary switchboard apparatus.

Indianapolis Light & Heat Co.,
Indianapolis, Ind.

Three hundred and twelve type I meters.

Jackson Gas Light Co., Jackson, Miss.

Three 100-light constant current transformers.

Two hundred arc lamps, each complete with reflector, hanger and cutout.

S. M. Jones Co., Toledo, O.

One MP 8-185-230-250 volt generator.

Knoxville Ry. & Light Co., Knoxville, Tenn.

Nine two-motor GE-67 equipments, with K-10 controllers.

Krell Piano Co., Cincinnati, O.

Eight 220 volt form K induction motors, ranging from 2 to 35 h. p. and aggregating 125 h. p.

One IS 4-½-1800-110 volt motor.

The above motor equipments will replace a complete mechanical drive system, formerly installed, which has been found unsatisfactory for their class of work.

T. I. Mooney & Co., Nashville, Tenn.

For Stahlman Building.

Two MP 6-100-245-125 volt generators.

One MP 6-50-275-125 volt generator.

One three-panel switchboard.

Nashville Ry. &. Light Co.,
Nashville, Tenn.

Nine 220 volt form K induction motors ranging from 3 to 25 h. p. and aggregating about 112 h. p.

One hundred and forty-two type I meters.

Two HC 20-1000-360-600 volt rotary converters, each complete with transformers, panels and accessories.

Two four-motor GE-57 equipments.

National Carbon Co., Cleveland, O.

One ATB 72-400-100-240 volt alternator.

One CL-B 6-30-700-125 volt exciter.

One 6-panel switchboard.

Six 220 volt form K induction motors, aggregating 235 h. p.

North Jellico Coal Co., Louisville, Ky.

One LM-106 C-1 36 in. gauge mining locomotive.

This Company has previously operated locomotives built by a competitor, and the obtaining of this order speaks well for General Electric locomotives. Two Curtis steam turbine-generators, of 75 kw. and 150 kw. capacity, have recently been sold this Company.

Platt Iron Works, Dayton, O.

One I 10-85-720-2080 volt form K induction motor.

This motor is for direct connection to a pump equipment manufactured by this Company.

Pope Motor Car Co., Indianapolis, Ind.

Ten Cat. No. 1020 automobile motors.

Portsmouth Street R. R. & Light Co.,
Portsmouth, O.

Sixteen GE-80 motors.

Proctor & Gamble Co., Cincinnati, O.

Four 440 volt form K induction motors, aggregating 37.5 h. p.

The above motors are all form K furnished complete with compensator, base frame and pulley.

The Proctor & Gamble Co. has installed at present a complete equipment of induction motors of competitive make, and this order was placed as an experimental proposition, to determine the merits of the General Electric product.

United States Locomotive & Equipment Co., Dayton, O.

Ninety-nine type H transformers, aggregating 466 kw.

Walling Power Co., McMinnville, Tenn.

One ATB 8-100-900-2300 volt form P alternator switchboard.

One panel.

Atlanta Office

Charleston Consolidated Ry., Light & Power Co., Charleston, S. C.

One MP 8-500-320-525/575 volt belted railway generator, with switchboard panel.

One CE 4-11-1200-125 volt belted exciter.

Newnan Cotton Mills, Newnan, Ga.

One ATB 6-1000-1200-600 volt Curtis steam turbine-generator.

One MP 6-15-400 "marine set" exciter.

One 17½ kw. motor generator set.

Switchboard.

Sixteen 60 cycle 550 volt induction motors aggregating 1380 h. p.

New Orleans Ry. & Light Co., New Orleans, La.

For Claiborne Street Station.

One switchboard to control the 3000 kw. 60 cycle Curtis steam turbine in the new 6600 volt power station.

Snow Steam Pump Co., Buffalo, N. Y.

For Georgia Railway and Electric Co., Atlanta, Ga.

One ATB 32-2000-94-6600 volt gas engine driven generator.

This unit is to act as reserve for the water power plant.

Foreign Dept.

A. E. G. Thomson-Houston, Milan, Italy

One 200 kw. brush arc motor generator set consisting of one ATB 10-200-500-8600 volt synchronous motor and two No. 13-A, form H four-circuit brush arc generators.

Switchboard panels.

Two hundred No. 31 double carbon brush arc lamps.

Bagnall & Hilles, Yokohama, Japan

One ATB 12-150-600-3450 volt water wheel driven generator.

Two OC 60-200-20,000-3120 volt transformers.

Three H 60-50-3120-220 volt transformers.

British Thomson-Houston Co., Ltd., Rugby, England

For Metropolitan Railways, London.

Four four-motor GE-69 Sprague-General Electric type M control equipments complete.

Eight trailer car equipments.

For South Wales Electric Distribution Co., Pontypridd, Glamorganshire, South Wales.

Four H 25-200-11,000-2300 volt transformers.

Four H 25-200-11,000-480 volt transformers.

Four OC 25-300-11,000-2300 volt transformers.

Four OC 25-500-11,000-2200 volt transformers.

Canadian Copper Co., Montreal, Que.

Nine 550 volt, three-phase 60 cycle induction motors with an aggregate capacity of 600 h. p., complete with necessary step-down transformers.

Canadian General Electric Co., Toronto, Ont.

Montreal Street Ry., Montreal, Quebec.

One MP 26-2000-100-550/600 volt railway generator.

One MP 14-1000-100-550/600 volt railway generator.

Forty-eight GE-80 railway motors.

Twenty complete air-brake equipments, including CP-21 air compressors.

Cananea Consolidated Copper Co., Cananea, Sonora, Mexico

One motor generator set consisting of an MP 4-250-720-260 volt generator direct connected to an I 10-360-720-2080 volt induction motor.

Switchboard.

Empress Electrica de Santa Rosa, Lima, Peru

Two ATB 36-1200-200-2300 volt water wheel driven generators.

French Thomson-Houston Co., Paris, France

Twelve WC 25-900-30,000-7500 volt transformers.

Thirty-six two-motor (200 h. p.) Sprague-General Electric type M control equipments. (Motors to be built by Ateliers Thomson-Houston, Paris.)

W. R. Grace & Co., New York, N. Y.

For La Paz Railroad, La Paz, Bolivia.

Two four-motor GE-53 railway equipments.

Guinle & Co., Rio de Janeiro, Brazil

For Nichteroy Lighting Plant, Nichteroy, Brazil.

One ATB 4-500-1800-2300 volt Curtis steam turbine-generator.

Havana Electric Railways, Havana, Cuba

One hundred two-motor GE-52 equipments with K-9 controllers.

Mexican Light & Power Co., Mexico City, Mexico

Three AB 50-500-18,600-3170/6340 volt transformers.

Mitsui & Co., Tokio, Japan

Two ATB 20-600-360-600 volt generators for direct connection to Escher Wyss water wheels.

One CL-B 6-25-900-125 volt belt driven exciter.

One motor generator exciter set consisting of one CL-B 6-25-900-125 volt direct connected to I 8-35-900-550 volt form K induction motor.

Four 550 volt form K motors, aggregating 525 h. p.

Switchboard.

One AHB 4-525-1800-185 volt Curtis steam turbine-generator.

One HC 16-500-450-250 volt rotary converter.

One 6-panel switchboard.

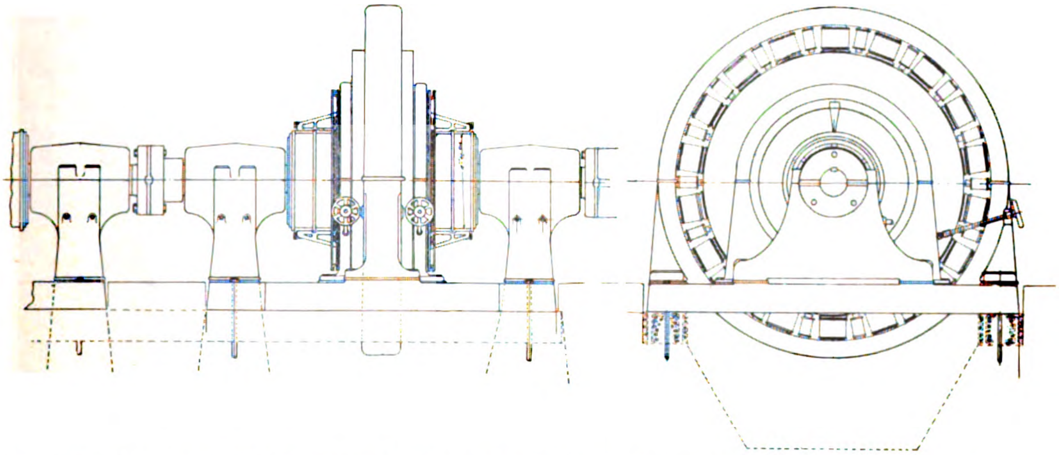
HIGH CAPACITY D.C. GENERATORS FOR THE PITTSBURG REDUCTION COMPANY'S NEW PLANT AT NIAGARA FALLS, N. Y.

By C. D. Knight, Engineering Dept.

A contract was recently closed with the Pittsburg Reduction Company of Pittsburg, Pa., for six 3540 kw. water wheel driven D.C. generators to be installed in one of that Company's new power houses at Niagara

Falls, the power to be supplied by the Niagara Falls Hydraulic Power and Manufacturing Co.

These machines are to be run in three tandem sets, of two machines each, each set operated by one 10,000 h. p. water turbine, as shown in the accompanying outline illustration. They will be the largest high speed D.C. generators in this country. The contract specifies machines having a range of voltage varying from 300 to 700, and capable of carrying continuously 6800 amp., or 25 per cent in excess of their rated current, at any point on the voltage range. The machines must also be able to stand a runaway speed of 450 rev. per min., or 50 per cent above their normal speed rating. These specifications, coupled with the fact that the machines are to be used under the severe conditions of electrolytic service, have made it necessary to introduce many novel features, both mechanical and electrical.



One of the High Capacity D.C. Generators for the Pittsburg Reduction Company's New Plant at Niagara Falls, N. Y.

The side view shows at the left the coupling and one bearing for the second machine of the set, and at the right the coupling for the water wheel which drives the two machines.

The machine will be equipped with commutating poles. The armature spiders will be constructed of semi-steel and the armature flanges of steel. Special methods are adopted for securing the heavy leads which connect the armature conductors with the commutator bars against the extraordinary strains due to centrifugal force and windage; and for cooling the under sides of the armature conductors, by longitudinal air ducts between conductors and core. The machine will have two commutators, of the shrink ring type. Each commutator will have nine sets of brushes: all of the positive brushes being on one commutator, and all of the negative brushes on the other. The standard practice in machines having two commutators on the same armature winding is to take half of the current from each commutator, using as many sets of brushes on each commutator as there are poles on the machine. By the present method of construction, however, in which the positive and negative brushes are on separate commutators, it will be impossible for the machines to flash over. Moreover this construction allows the diameter of the commutators, and consequently their peripheral speed, to be reduced. The brush-holder yokes will be supported from the base of the machine at a point nearly beneath the middle of the commutator, the brushes being supported on brush holder brackets extending each side of the yoke. This construction gives a rigid support for the brushes, and facilitates inspection and adjustment.

The bearings will be of the latest ring oiling type, the oil tanks of each bearing being provided with a cooling coil.

The sale of these machines was reported on page 92 of the April, 1906, issue of the Review.

SAN FRANCISCO OFFICE NOTES

The way in which the recent damage from earthquake and fire in San Francisco has been met furnishes a gratifying instance of American business enterprise in the face of disaster. The earthquake took place shortly after five o'clock Wednesday morning, April 18, and was immediately followed by the fire which completed the destruction of so large a portion of the city. The following extract from a letter from Dr. Addison, Manager of the General Electric Company's San Francisco Office, written the next day but one after the disaster, gives a graphic picture of the scene "at the front" and at the same time shows the courageous and wide-awake spirit of the General Electric Company's representatives at San Francisco.

Oakland, Cal., April 20, 1906

MR. J. R. LOVEJOY, ESQ.
Schenectady, N. Y.

DEAR SIR:

I assume the press despatches have given you a full account of the awful earthquake and fire at San Francisco; therefore, I shall not attempt to go into any details.

The earthquake occured at 5.13 A. M. day before yesterday, the fire beginning soon after. It began along the water front near the ferry building, and by 8.30 A. M. when I tried to get into the city on the regular train and boat from Berkeley, the military were in control and we were not permitted to land, and I could not get into the city that day. Yesterday morning I succeeded in getting into the city and up Market Street as far as the Palace Hotel and in front of our own building, the Crossley. It was a mass of ruins and had been burnt the day before. I then succeeded in getting through to Townsend Street, where our warehouse had been. It too had been burnt the night before.

Some of our clerks who lived in the city got into our office in the Crossley building in the early morning hours, and succeeded in getting out some of our stock cards and other papers, but so far as I now can ascertain, they were obliged to abandon them during that day and night in order to save themselves.

About a month ago we succeeded in getting possession of an old warehouse south of the railroad tracks, and had begun to use it as an overflow and had moved into it some transformers and motors. This overflow stock was not burnt but the building was wrecked by the earthquake. I think however, we will be able to save most of that stock, but all the rest of our stock including our entire office furniture, books, accounts, tickets, etc., etc., was destroyed.

My tour of the city yesterday morning was perhaps five miles in extent through the business and warehouse territory. At that time there was not a hotel or a bank or a retail or wholesale store of any description left in the business part of the town, and the fire has been raging furiously ever since. I then became convinced that it was absolutely impossible for us to continue business in San Francisco; no matter how rapidly it may build up, it will be the better part of a year before we can return to it. I talked with a number of business men and all coincided with my opinion as above.

I then came to this city and succeeded in getting a suite of seven rooms in the Union Savings Bank Building. Ten minutes after I had secured these rooms, every other room in the building was taken by the Southern Pacific Company, and the representatives of a hundred other firms of San Francisco are now walking in the streets trying to find a place in which to open their business.

So far as I know, our office force escaped alive, many of them losing everything but the clothes they had on. We are taking up actively the question of a temporary warehouse, but as yet I have no recommendations to make regarding that. We are also trying to get hold of our accumulated mail and telegrams from the post office and telegraph companies respectively, and in every way get ready for business as soon as possible.

(Signed) THOS. ADDISON
Mgr. S. F. Office

Immediately upon receipt of news of the disaster measures were adopted for the relief and assistance of the San Francisco Office. Reference is here made only to the measures adopted to take care of the business loss and confusion that befell the San Francisco Office, and not to any of the subscriptions that were promptly started for the relief of private losses among the office employees. With the exception of one laborer, all of the employees escaped with their lives, although a number were residing in the devastated district at the time.

Mr. M. F. Westover, Secretary of the General Electric Company, left for San Francisco on Saturday, April 21, primarily to look after the insurance interests of the Company. The shipment of apparatus and supplies was taken energetically in hand. The first shipment from Schenectady was made on April 23 and consisted of two cars loaded with miscellaneous apparatus and supplies. On the 24th three cars were shipped, and shipments of apparatus and supplies from Schenectady, Lynn and Pittsfield have been made at the rate of from one to three cars per day, aggregating fifty-two cars to date (May 17) including one car of transformer oil from Rochester and one car of special building material from Quincy, Mass. These shipments included a number of large lots, such as eight car loads of miscellaneous lighting supplies, six cars of transformers, four cars of wire, two cars of arc lamps, etc., etc. The Chicago Office immediately offered to take care, from its stock, of any customers' orders that the San Francisco Office might send along, and on April 27 sent for San Francisco office stock a car of general supplies.

An interesting feature of the Transportation Department's work in connection with the San Francisco disaster was the location of all freight cars that were already on the road at the time of the disaster. Each of the forty-two cars that were on the way—viz, nineteen cars from Schenectady, seventeen from Lynn and six from Pittsfield—was located by telegraph, and an analysis of its contents was made from the shipping lists, in the thirty hours between ten a. m. April 19 and four p. m. April 20. All of the material on the road was thus placed subject to orders from the front, and the Transportation Department was in a position to divert, by telegraphic orders, any given shipment originally destined for San Francisco direct, to points North and South thereof.

As a matter of fact, such diversion of the freight already en route did not become necessary, as requests were received from the San Francisco Office to let all of the freight come through direct to San Francisco. A letter dated April 30 from Mr. T. E. Bibbins, Manager Supply Department, San Francisco Office, stated that a strip of land had been secured at Emery, a station in Oakland, situated on the Southern Pacific Railroad and adjacent to the Santa Fe Railroad, and just opposite the power house of the Key Route System. A temporary one-story warehouse having 40,000 sq. ft. of floor space has been erected on this plot, which has ample accommodation for storing and handling all material as it arrives. To relieve the congestion that would otherwise occur at San Francisco later on, a large warehouse has been leased at Los Angeles, and additional warehouse space has been secured at Portland, Oregon.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

The Hydro-Electric Plant of the Animas Power & Water Co.

[Elec. Rev., Apr. 21, 1906, p. 610.]

A very interesting article containing a map and general illustrations. The water from a number of small creeks is stored in the Cascade Reservoir for supplying a power house, which is laid out for an initial equipment of two and an ultimate equipment of three Pelton water wheel driven 2250 kw. 300 rev. per min., 4000 volt, 60 cycle three-phase alternators with direct connected exciters, six 750 kw. 4000 50,000 volt transformers, and an elaborate switchboard installation, all of General Electric Company make.

Hydro-Electric Development in the Adirondacks

[El. Wld., Apr. 21, 1906, p. 819.]

An illustrated description of the combined hydro-electric power house and pulp mill of the Hannawa Falls Water Power Co. located near Colton Village, N. Y., on the Raquette River. This plant is equipped with turbines aggregating 575 h. p., driving pulp making machinery, and with several 4400 volt, 60 cycle three-phase generators including four 350 kw. units of General Electric make. Part of the power is distributed to Potsdam, and part is transmitted to Ogdensburg and Gouverneur, at a line potential of 20,000 volts, for railway purposes and for general power and lighting.

Design of Hydro-Electric Power Stations

[Elec. Wld., Mar. 31, 1906, p. 670.]

An abstract of a paper, read by Mr. D. B. Rushmore at the March 23 meeting of the American Institute of Electrical Engineers, in which a number of points of interest are discussed.

The New Leominster Line of the Worcester Consolidated Ry. Co.

[St. Ry. Rev., Apr. 15, 1906, p. 205.]

The new sixteen mile line connecting Worcester with Leominster will be supplied from a power station located at Leominster Park and containing steam engines and water wheels of a combined aggregate output of about 1500 h. p. The electrical machinery is of General Electric make and comprises two 150 kw., 600 volt D.C. generators, and two 400 kw. three-phase alternators, for feeding the trolley line direct, and for supplying a rotary converter sub-station located at West Boylston, respectively. The article is illustrated by a map of the line and a drawing of the transformer house.

A Colliery Haulage Problem

[Eng. & Mining Jour., Apr. 14, 1906, p. 697.]

A brief description of the reduction of the cost of mining at the "Dagus 1" pit of the Northwestern Mining & Exchange Co. at Dagus Mines, Pa., by the use of electric locomotives. It is stated that two 10 ton General Electric mining locomotives are taking the place of at least sixty mules hauling about 800 tons of coal per 10 hour day.

Modernizing the Comstock Lode

[Jour. of El. Pr. & Gas, April 1906, p. 171.]

An illustrated description of one of the Union Shaft Company's shafts equipped with a 100 h. p., 450 rev. per min., 460 volt General Electric induction motor driven hoist, of the balanced tail-rope type with an auxiliary sinking drum. The capacity of this hoisting engine is about 500 tons per day, hoisted from a depth of 2000 ft. Three 40 kw. 2240/460 volt General Electric transformers supply power to the hoist motor, and to a number of other applications on the surface including a 20 h. p. General Electric motor driven swing saw for the mine timber carpenter shop.

New Mechanical Equipment at the Joseph Campbell Factory, Camden, N. J.

[Eng. Rec., April, 21, 1906, p. 510.]

The extensive factory of the Joseph Campbell Co. at Camden, N. J., one of the largest food product manufacturers in this country, is equipped with a large number of electrically driven machines. General Electric motors ranging from ¼ to 20 h. p. are used for individual drive, and several Sprague cranes and motor hoists are supplied from a 50 kw., 110 volt General Electric generator.

Largest Power Station in Japan

[Elec. Age, April 1906, p. 291.]

The new plant of the Tokio Electric Light Co. is located twenty-five miles from Tokio and utilizes the water power of the Tamagawa River. The electrical equipment will comprise five 3900 kw., 6600 volt, 50 cycle water wheel driven three-phase generators, nine 2000 kw. 6600-35000/57000 volt step-up transformers and nine 1600 kw. 57000/33000-11000 volt step-down transformers. This apparatus, as well as the entire switchboard equipment for the main station and the sub-stations, will be furnished by the General Electric Company.

The Work of the Lewiston and Auburn Electric Light Company

[Elec. Wld., Apr. 14, 1906, p. 789.]

The main generating station of this Company, situated on the Androscoggin River, contains two 750 kw., 180 rev. per min. 10,000 volt, 60 cycle water wheel driven three-phase alternators, and a third 750 kw. unit is soon to be installed. There are also two auxiliary plants equipped with belt driven 180 kw. units. 10,000 volt, three-phase, 2200 volt two-phase transformers supply Lewiston and Auburn with current for lighting and power, and rotary converters furnish current for operating the Auburn & Turner R. R. and the Lewiston, Brunswick & Bath Street Ry. All of the electrical machinery and enclosed arc lamps are of General Electric make, and a number of Meridian and high efficiency incandescent lamps are installed.

The Construction of the Utica Station of the Hudson River Electric Company

[Eng. Rec., Apr. 21, 1906, p. 516.]

This station has been using a temporary installation of 750 kw. Curtis steam turbine-generators, and the ultimate permanent installation will consist of three 2000 kw. and two 1000 kw. Curtis steam turbine-generators furnishing power to the Utica & Mohawk Valley Ry. Co. The article is illustrated by views showing the progress of the construction work.

Artificial Illumination—XI: Interior Illumination, Continued

[Elec. Age, April, 1906, p. 275.]

This well illustrated article is largely devoted to the arrangement of ordinary incandescent lamps in private houses, restaurants, hotels, banks, etc. but also describes the application of several special lamps, including General Electric lamps with helical and conical shaped filaments for use in stereopticons, in headlights and for surgical and microscopical purposes.

General Electric Company Review, May, 1906

INDEX

	Page
Abstracts of Important Technical Articles	14
Generating Systems:	
Lewiston & Auburn Electric Light Company, The Works of the	14
(See also "Motor Drive" and "Transmission.")	
Generators, High Capacity D.C., for the Pittsburg Reduction Company's New Plant at Niagara Falls, N. Y., by C. D. Knight	10
Heating Devices, Electric—Note	4
Illumination, Artificial: Part XI: Interior Illumination, continued	14
Lighting (See "Illumination.")	
Motor Converter, The, by H. F. T. Erben	4
Motor Drive:	
Comstock Lode, Modernizing the	14
(Food Product) Factory, New Mechanical Equipment at the Joseph Campbell, Camden, N. J.	14
Recent Important Sales	5
San Francisco Office Notes	12
Traction:	
Colliery Haulage Problem, A	14
Leominster Line, The New, of the Worcester Consolidated Ry. Co.	14
(See also "Generating Systems.")	
Transformers, High Voltage, of Large Capacity, by W. S. Moody	1
Transmission:	
Adirondacks, Hydro-Electric Development in the	14
Animas, Power & Water Co., The Hydro-Electric Plant of the	14
Japan, Largest Power Station in	14
Stations, Design of Hydro-Electric Power	14
(See also "Generating Systems.")	
Turbine Installation:	
Utica Station of the Hudson River Electric Company, The Construction of the	14

RECENT INSTALLATIONS, CONTRACTS AND SALES

		Page
Adams Express Co.	New York, N. Y.	5
Allegheny County Light & Power Co.	Pittsburg, Pa.	5
A. E. G. Thomson-Houston	Milan, Italy	10
Alton, Granite & St. Louis Traction Co.	Alton, Ills.	6
American Railways Co.	Philadelphia, Pa.	7
American Smelters Securities Co.	New York, N. Y. & Flat River, Mo.	6
Anaconda Copper Mining Co.	Anaconda, Mont.	6
Animas Water & Power Co.	La Plata County, Colo.	14
Astoria Electric Co.	Astoria, Ore.	8
Ateliers Thomson-Houston	Paris, France	10
Auburn & Turner R. R. Co.	Auburn, Me.	14
Bagnall & Hilles	Yokohama, Japan	10
Balakalala Consolidated Copper Co.	Kennett, Cal.	8
Beacon Light Co.	Chester, Pa.	7
Billings Water Power Co.	Billings, Mont.	6
Boston Machine Shop Co.	Oroville, Cal.	8
Bowers Rubber Works	San Francisco, Cal.	8
British Thomson-Houston Co., Ltd.	Rugby, England	10
Brunswick-Balke-Collender Co.	Long Island City, N. Y.	5
Buffalo General Electric Co.	Buffalo, N. Y.	5
California Gas & Electric Co.	San Francisco, Cal.	8
Campbell Co., Joseph	Camden, N. J.	14
Canadian Copper Co.	Montreal, Que.	10
Canadian General Electric Co.	Toronto, Ont.	10
Cananea Consolidated Copper Co.	Cananea, Sonora, Mexico	10
Caribou Water, Light & Power Co.	Caribou, Me.	6
Central Illinois Construction Co.	Peoria, Ills.	6
Charleston Consolidated Ry., Light & Power Co.	Charleston, S. C.	10
Chicago & Southern Traction Co.	Chicago, Ills.	6
Citizens Gas & Electric Co.	Waterloo, Iowa	7
Citizens Ry. Co.	Lincoln, Neb.	7
Columbia Improvement Co.	Boston, Mass.	6, 8
Columbus Northern Ry., Power & Equipment Co.	Columbus, O.	9
Commonwealth Electric Co.	Chicago, Ills.	7
Consolidated Electric Light & Power Co.	Kansas City, Mo.	7
Consolidated Ry. Co.	New Haven, Conn.	5
Conrey Placer Mining Co.	Ruby, Mont.	7
Copper Queen Consolidated Mining Co.	New York, N. Y. & Morrence, Ariz.	5
Cramp, Wm., & Sons Ship & Engine Building Co.	Philadelphia, Pa.	7
Decatur Ry. & Light Co.	Decatur, Ills.	7
Department of the Interior, United States Geological Survey	Washington, D. C., and Roosevelt, Ariz.	8
East St. Louis & Suburban Ry. Co.	East St. Louis, Ills.	7
East Shore Suburban Ry. Co.	Richmond, Cal.	8
Edison Electric Co.	Los Angeles, Cal.	8
Electrical Development Co.	Niagara Falls, Ont.	2
Empress Electrica de Santa Rosa	Lima, Peru	10
Fort Worth Light & Power Co.	Fort Worth, Tex.	7
Frazer, Robert	Utica, N. Y.	5
French Thomson-Houston Co.	Paris, France	10
General Electric Co.	Chicago, Ills.	13
General Electric Co.	Lynn, Mass.	13
General Electric Co.	Schenectady, N. Y.	1
General Electric Co.	Portland, Ore., & Los Angeles, Oakland & San Francisco, Cal.	12, 13
Geological Survey, U. S.	(See "Department of the Interior.")	
Georgia Ry. & Electric Co.	Atlanta, Ga.	10
Grace & Co., W. R.	New York, N. Y.	10
Great Northern Power Co.	Duluth, Minn.	3
Guinle & Co.	Rio De Janeiro, Brazil	10

		Page
Hannawa Falls Water Power Co.	Colton Village, N. Y.	14
Havana Electric Railways	Havana, Cuba	10
Herkimer County Light & Power Co.	Little Falls & Dolgeville N. Y.	5
Holyoke City Government	Holyoke, Mass.	6
Houston Electric Co.	Houston, Tex.	6
Hudson River Electric Co.	Utica, N. Y.	14
Hudson River Electric Power Co.	Glens Falls, N. Y.	5
Illinois Valley Ry. Co.	La Salle, Ills.	7
Indianapolis Light & Heat Co.	Indianapolis, Ind.	9
International Steam Pump Co.	New York, N. Y.	8
International Traction Co.	Buffalo, N. Y.	5
Jackson Gas Light Co.	Jackson, Miss.	9
Jones, S. M., Co.	Toledo, O.	9
Juniata Hydro-Electric Co	Philadelphia & Warrior Ridge, Pa.	7
Kansas City Western Ry. Co.	Kansas City, Mo.	7
Knoxville Ry. & Light Co.	Knoxville, Tenn.	9
Krell Piano Co.	Cincinnati, O.	9
La Paz Railroad	La Paz, Bolivia	10
Lewiston & Auburn Electric Light Co.	Lewiston, Me.	14
Lewiston, Brunswick & Bath Street Ry. Co.	Lewiston, Me.	14
Long Island R. R. Co.	Richmond, Long Island, N. Y.	6
Los Angeles Gas & Electric Co.	Los Angeles, Cal.	8
Lynchburg Traction & Light Co.	Lynchburg, Va.	7
Metropolitan Railways	London, England	10
Mexican Light & Power Co.	Mexico City, Mexico	10
Milton City Government	Milton, Ore.	8
Mitsui & Co.	Tokio, Japan	10
Montreal Street Ry.	Montreal, Que.	10
Mooney & Co., I. T.	Nashville, Tenn.	9
Moore & Co., Chas. C.	San Francisco, Cal.	8
Manchester Electricity Works	Manchester, England	5
Muskogee Electric Traction Co.	Muskogee, Ind.	7
Nashville Ry. & Light Co.	Nashville, Tenn.	9
National Carbon Co.	Cleveland, O.	9
Newnan Cotton Mills	Newnan, Ga.	10
New Orleans Ry. & Light Co.	New Orleans, La.	10
Niagara Falls Hydraulic Power & Mfg. Co.	Niagara Falls, N. Y.	11
Nichteroy Lighting Plant	Nichteroy, Brazil	10
Niles-Bement-Pond Co.	Philadelphia, Pa.	7
Norfolk & Southern R. R. Co.	Norfolk, Va.	7
North Jellico Coal Co.	Louisville, Ky.	9
North Shore Electric Co.	Blue Island, Ills.	7
Northwestern Mining & Exchange Co.	Dagus Mines, Pa.	14
Oklahoma Gas & Electric Co.	Oklahoma City, Okla.	7
Ophir Gold Dredging Co.	San Francisco, Cal.	8
Ottumwa Ry. & Light Co.	Ottumwa, Iowa	7
Oxnard Construction Co.	New York, N. Y.	8
Pacific Coast Mfg. Co.	Los Angeles, Cal.	8
Pacific Coast Oil Co.	Richmond, Cal.	8
Pacific Gas & Electric Co.	San Francisco, Cal.	8
Pacific Portland Cement Co.	Cement, Cal.	8
Pacific States Telephone & Telegraph Co.	San Francisco, Cal.	9
Pennsylvania Coal Co.	Old Forge Colliery, Pa.	8

		Page
Pennsylvania R. R. Co.	Philadelphia Atlantic City, Pa.	8
Pennsylvania Steel Co.	Philadelphia, Pa.	8
Philadelphia Electric Co.	Philadelphia, Pa.	8
Philadelphia Rapid Transit Co.	Philadelphia, Pa.	8
Philadelphia & West Chester Traction Co.	Philadelphia & Llanerch, Pa.	8
Pittsburg Reduction Co.	Niagara Falls, N. Y.	10
Platt Iron Works	Dayton, O.	9
Pope Motor Car Co.	Indianapolis, Ind.	9
Portland General Electric Co.	Portland, Ore.	9
Portsmouth Street R. R. & Light Co.	Portsmouth, O.	9
Potomac Electric Power Co.	Washington, D. C.	8
Proctor & Gamble Co.	Cincinnati, O.	9
Public Service Corporation	Newark, N. J.	6
Puget Electric Ry. Co.	Tacoma, Wash.	9
Rochester Ry. Co.	Rochester, N. Y.	6
Saco & Pettee Machine Shops	Newton Upper Falls, Mass.	6
St. Paul Gas Light Co.	St. Paul, Minn.	7
San Diego Electric Ry. Co.	San Diego, Cal.	9
San Francisco Gas & Electric Co.	San Francisco, Cal.	9
San Francisco, Oakland & San José Ry.	Oakland, Cal.	9
Scranton Electric Construction Co.	Scranton, Pa.	8
Seattle Electric Co.	Seattle, Wash.	9
Shawnee & Tecumseh Co.	Shawnee, Okla.	7
Snow Steam Pump Co.	Buffalo, N. Y.	10
Southern Illinois Traction Co.	Peoria, Ills.	1
Southern Michigan Ry. Co.	South Bend, Ind.	7
Southern Power Co.	Charlotte & Old Point, N. C.	8
South Wales Electric Distribution Co.	Pontypridd, Glamorganshire, England	10
Sprague Electric Co.	New York, N. Y.	14
Stanley G. I. Electric Mfg. Co.	Pittsfield, Mass.	13
Stone & Webster	Boston, Mass.	6
Thompson Starrett Co.	New York, N. Y.	6
Ticonderoga Pulp & Paper Co.	Ticonderoga, N. Y.	6
Tokio Electric Light Co.	Tokio, Japan	14
Tri City Ry. Co.	Davenport, Ia.	7
Union Gold Dredging Co.	Centerville, Ida.	9
Union Shaft Co.	Virginia City, Nebr.	14
United States Cast Iron Pipe & Foundry Co.	New York, N. Y. & Burlington, N. J.	8
United States Express Realty Co.	New York, N. Y.	6
United R. R. of San Francisco	San Francisco, Cal.	9
United States Locomotive Equipment Co.	Dayton, O.	10
Utica & Mohawk Valley Ry. Co.	Utica, N. Y.	14
Walling Power Co.	McMinnville, Tenn.	10
Washington Water Power Co.	Spokane, Wash.	9
West Jersey & Seashore R. R. Co.	Philadelphia, Pa.	8
Witherbee Sherman Co.	Mineville & Port Henry, N. Y.	6
Worcester Consolidated Ry. Co.	Leominster & West Boylston, Mass.	14
Yegen Brothers	Billings, Mont.	7

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GENERAL ELECTRIC COMPANY REVIEW

Vol. VII SCHENECTADY, N. Y., JUNE, 1906 No. 2

THE STEAM TURBINE

By Charles P. Steinmetz

While the steam turbine principle was used in the earliest type of steam engine, and the hydraulic turbine has been developed to a high degree of perfection quite some time ago, the modern steam turbine is a product of the last few years only. The reason for this delay in development is found in the very high spouting velocity of steam, a velocity of the order of magnitude of that of a rifle bullet. This high velocity of the steam jet requires for economical utilization such high peripheral velocities of rotating wheels—from 300 to 500 ft. per sec.—as have become practicable only during recent years.

The differences between steam turbines and hydraulic turbines are, therefore, the constructive differences resulting from the high rotative speeds required in the former. In the hydraulic turbine, spouting velocities as high as 200 ft. per sec., are rare, and in most cases the velocity is far below that order; while the velocities of the steam jets used in the steam turbine are from 1500 to 3000 ft. per sec.

In the steam turbine, the potential energy of the admitted steam is converted into the kinetic energy of the steam jet, and the kinetic energy of the steam jet into the kinetic energy of the revolving wheel. This double transformation can take place either simultaneously in the same wheel (reaction turbine), or successively in stationary nozzles and revolving wheels (action or impulse turbine).

In the reaction turbine, steam enters the revolving wheel at admission pressure but at moderate velocity, expands in the wheel and leaves the wheel at the velocity of expansion relatively to the wheel, that is, at an absolute velocity equal to expansion velocity minus wheel velocity. To take the full energy out of the steam, it must leave the wheel at zero absolute velocity: that is, the wheel velocity must equal the velocity of the steam jet.

In the impulse turbine, the steam expands in a separate nozzle, strikes the rotating wheel at expansion pressure and expansion velocity, and rebounds therefrom, as an elastic body, with the same velocity as that with which it strikes, hence losing velocity by an amount equal to twice the wheel velocity. To take the full energy out of the steam, the wheel velocity must therefore equal one-half the velocity of the steam jet.

In an impulse turbine, therefore, such as the DeLaval or Curtis turbine, with a given pressure range per wheel the wheel velocity at best efficiency is only about 50 per cent of what it is in a reaction turbine, and $\frac{1}{\sqrt{2}} = 70$ per cent of what it is in a combination turbine alternating between impulse and reaction effect, such as the Parsons turbine.

Since the most difficult condition of turbine design is the high rotor velocity required to utilize the high steam velocity, the impulse turbine is theoretically superior. It is not possible to get efficiency with a single turbine wheel of the reaction type, while with a single wheel of the impulse type good efficiencies have been reached by using extremely high peripheral speeds (DeLaval turbine). In general, however, while hydraulic turbines are always designed with a single wheel, in the steam turbine it is not possible to make effective use of the total energy of the steam by a single wheel, but a number of wheels in series have to be used. That is, the rotor velocity is reduced by sub-dividing the total pressure range into a number of successive stages. In the combination impulse and reaction turbine of Parsons, each expansion or pressure stage requires a revolving wheel and a stationary guide wheel. The latter acts as nozzle wheel in which the steam expands, acquiring a velocity equal to the velocity of the revolving wheel. At the entrance into the revolving wheel, this velocity is transferred to the wheel on the impulse turbine principle, and the steam in passing through the revolving wheel expands again, leaving it with wheel velocity. That is, the revolving wheel of the Parsons turbine is impulse wheel at the entrance, reaction wheel at the exit side.

The impulse turbine requires for each expansion stage a separate system of nozzles, hence, while requiring only 70 per cent of the number of expansion stages which are required by a Parsons turbine with the same wheel velocity, each stage is more complicated, so that it is questionable whether the single wheel multistage impulse turbine can rival the combination turbine of Parsons.

In the impulse turbine, in which the expansion of the steam is carried out separately from the transformation into mechanical rotation, a further and still more effective means of speed reduction is presented by the use of several velocity steps in each stage: that is, by imparting the velocity of the current of steam to a number of successive wheels composing a single revolving disk, with stationary intermediate guide wheels.

Since in a revolving wheel of an impulse turbine the steam velocity is reduced by an amount equal to twice the wheel velocity, a single wheel per stage must revolve at one-half the steam velocity, two wheels per stage at one-quarter the steam velocity, etc. The use of several wheels per stage, therefore, is a more effective means of reducing the rotor speed—or inversely, at given rotor speed, reducing the total number of revolving wheels—than the use of several expansion steps. A two-wheel stage can take care of twice the steam velocity (that is, four times the steam energy) of a single-wheel stage, and therefore replaces four single-wheel stages. Or, in other words: the speed reduction of the rotor is proportional to the number of wheels per stage, that is, the number of velocity steps, but only proportional to the square root of the number of stages, that is, number of pressure steps.

The simultaneous use of pressure steps, or expansion stages, and velocity steps, or number of wheels per stage, therefore leads to a construction requiring a very small total number of wheels only, as carried out in the Curtis type of turbine.

To illustrate: Assume a total steam velocity of 4000 ft. per sec., corresponding to a given pressure range from boiler to condenser. Allowing 10 per cent velocity loss, the available velocity would be 3600 ft. per sec., and two stages of three wheels per stage, or a total of six revolving wheels, would give a spouting velocity of the steam per stage of $\frac{3600}{\sqrt{2}} = 2550$ ft. per sec., and therefore a wheel velocity of $\frac{2550}{6} = 425$ ft. per sec.

With a wheel velocity of 425 ft. per sec., a single impulse wheel would utilize only 2x425=850 ft. per sec. steam velocity, and $(\frac{3600}{850})^2 = 18$ stages or successive steps of expansion would be required, that is, 18 revolving wheels, each with a set of nozzles, etc.

With a wheel velocity of 425 ft. per sec., in a reaction turbine, $(\frac{3600}{425})^2 = 72$ successive expansions would be required: e. g., in a Parsons turbine, if this condition could be realized, 36 revolving and 36 stationary wheels.

In the Curtis turbine, two methods of sub-dividing the steam energy are available—pressure steps or stages, and velocity steps or wheels per stage. Obviously, a single pressure step or stage with a considerable number of successive wheels, or a large number of stages each with a single wheel, could be used, but both of these extreme arangements would be inefficient, and the relative distribution of work between pressure steps and velocity steps depends upon considerations of efficiency.

The main losses in a steam turbine are:

(1) Wheel friction. The wheels revolve in an atmosphere of steam, which has a remanent velocity several times greater than any tornado which ever devastated the country. This loss decreases with the decreasing number of wheels. Hence it is a maximum, other things being equal, with the reaction type of turbine, and diminishes with decrease in the total number of wheels, i. e.. with increase in the number of wheels per stage.

(2) Bucket friction, or friction in the steam passages in revolving wheels and guide wheels. This loss depends upon the relative velocity of steam and wheel, hence is a minimum for the reaction turbine, where the average relative velocity is only half the wheel velocity. In a single wheel impulse turbine, the relative velocity is the wheel velocity, and increases with increasing number of wheels per stage, that is, increasing number of velocity steps. It is this loss which finally limits the number of wheels permissible per stage.

(3) Nozzle losses, which at first decrease with decreasing pressure range—that is, decrease with decreasing work done per nozzle, or in other words with increasing number of stages—but then increase again, due to the lesser accuracy of operation feasible with very many successive nozzle wheels.

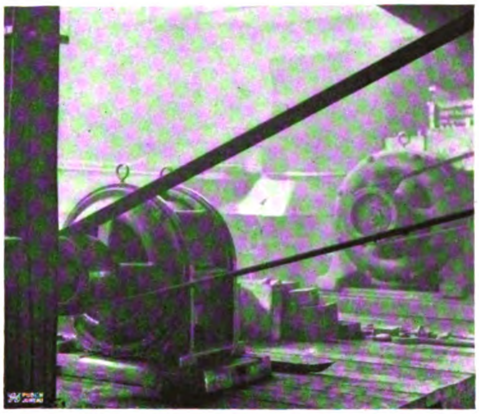
(4) Steam leakage from stage to stage. Leakage losses are very much greater in the reaction turbine, where pressure differences exist across the revolving wheels, become small with impulse turbines, and would disappear in an impulse turbine using many wheels in a single stage.

As seen, then, if we consider the losses as a function of the total number of revolving wheels, some losses, such as (1) and (4), increase, others, such as (2), decrease with increasing number of wheels, and the problem of turbine design is to determine that intermediate point, at which the total sum of the losses is a minimum, that is, the efficiency a maximum.

GENERAL ELECTRIC INDUCTION MOTORS OPERATING UNDER TRYING CONDITIONS

The accompanying illustration is reproduced from a photograph of an installation of General Electric Company induction motors at the factory of the Standard Sausage Company, Chicago, in a room which is ordinarily filled with steam.

The left hand motor is a I 6-20-1200-220 volt Form K machine of the new General Electric type, belted to a line shaft to which are belted meat-choppers and other machines used in sausage making. The motor shown at the right is one of the superseded type General Electric induction motors. What appears to be smoke in the background is steam, which is ordinarily so thick in the room that before the photograph could be taken, even with bright sunshine coming through the skylight from above, it was necessary to ventilate the room thoroughly by opening the windows.



Induction Motors Installed in the Standard Sausage Company's Factory, Chicago, in a Room Filled With Steam

Current for operating these two motors is furnished by the Commonwealth Electric Company. The steam, which is needed in the process of sausage manufacture, is usually obtained from the exhaust of a steam engine used to drive the machinery, so that the electric motor has had an uphill fight to gain a foothold in this branch of manufacture.

COMMERCIAL TEST OF INDUCTION MOTORS

By E. B. Raymond

All of the characteristics of every new piece of electrical apparatus designed by the General Electric Company are determined by actual test before the apparatus is put into production.

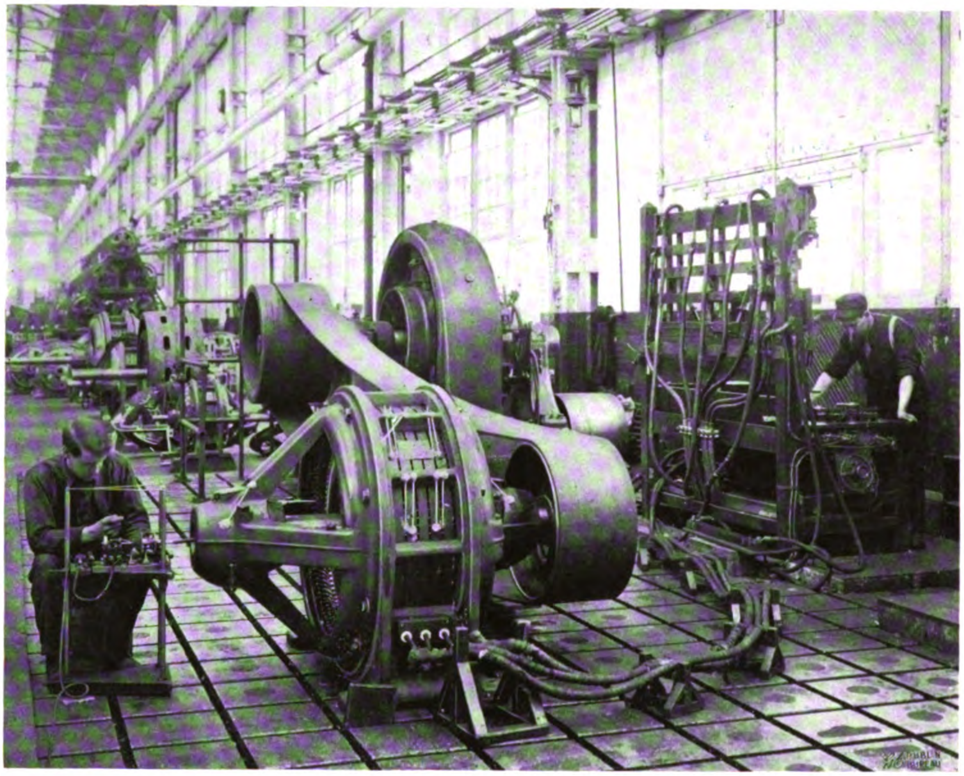


Fig. 1

Testing the Slip on an I 6-150-500-2080 Volt Induction Motor

The motor is belted to another machine of about the same capacity and run without load at 115 per cent. of normal voltage. The man at the motor is taking readings on the slip device. The man at the testing stand is holding voltage. The view illustrates the small number of men required to handle induction motors by the Commercial Test.

For an induction motor, these characteristics, which are presented in the accompanying curves, Figs. 2 to 5 inclusive, are as follows:

Maximum Output (Fig. 2)

At maximum output the efficiency, power factor and speed begin to fall off, and the current to increase, so rapidly as to give an unstable condition of running. An induction motor should therefore be operated well within its maximum horse power output.

Commercial and Apparent Efficiency, Power Factor, Slip, Current, and Torque, at All Loads (Fig. 2)

The commercial efficiency is the ratio of the output to the input, and for a commercial line of machines should always be as high as may be compatible with economical design and construction. There are cases where, for various reasons, it may be desirable to obtain extraordinarily high efficiency or some other special characteristic regardless of cost; but these cases do not come within the scope of this article.

The apparent efficiency is the ratio of the output to the apparent input. Since the power factor—which is the ratio of the true energy or watts input as measured by a wattmeter, to the apparent energy as given by multiplying together the effective values of current and pressure—is never unity, the apparent efficiency is always lower than the commercial efficiency.

The slip is the difference between the actual running speed at a given load and the synchronous speed. The speed at which the maximum torque is given depends upon the amount of resistance in the rotor circuit. For all rotor circuit resistances between the value giving maximum torque at starting and the value with external resistance all cut out, the maximum torque is independent of this resistance; the speed at which the maximum torque is given, however, being increased as the resistance is cut out.

Torque and Amperes at Various Speeds From Rest to Synchronism (Fig. 3)

For squirrel cage motors (form K) these characteristics are shown in the amperes and watts curves for short circuited rotor.

For motors having starting resistance in the rotor circuit (form L and form M motors), these characteristics are shown for several starting resistances, giving an amperes curve and a watts curve for each. In the starting resistance of an induction motor, designed for usual conditions, it is well to have the first step at which the motor starts of such value that the torque at starting is approximately equal to the full load torque. The graduations of resistance should be such as to give as nearly as possible a uniform increase in speed, up to maximum speed with the resistance all out, after which the load on the motor regulates the speed and the torque.

Excitation (Fig. 4) and Impedance (Fig. 5)

The "excitation" is the amperes and watts taken by the motor when running light, at various voltages applied. The "impedance" is the amperes and watts taken by the motor standing still, at various voltages applied. The watts curves plotted from the excitation and impedance tests give a record of the distribution of the losses in the motor: viz, windage and bearing friction loss, core loss, and I^2R losses in stator and rotor.

During the entire time that the machine is being run to obtain the test data from which the above characteristics are computed, the motor is carefully observed for defects: such as noisy operation, imperfect balance, lack of proper end play, leaking or throwing of oil, heating of bearings, etc. In addition, the temperature of the different parts of the motor, when running at full load and at various overloads, is measured after running the motor long enough to bring all of its parts to a constant temperature.

Special starting tests are made on the Form L motors with starting switch. These motors are started several hundred times under normal load or overload, in order to test the practical operation of the switch, and detect any possible weakness of design which might affect the life of the switch or its ability to carry safely the heavy currents passing through it without sparking and consequent burning of the contact surfaces.

While it is necessary, in order to obtain these complete data, to make exhaustive electrical, mechanical and thermal observations, constituting the "Special Test," on one or two motors of each type and size, after the complete data have been obtained on these motors, the remaining motors may be depended upon to give, for all practical purposes, similar results; so that instead of having to repeat all of the tests on the remaining motors, it is only necessary to take certain readings which are so related to the designing factors of the motors as to serve as checks on the data already determined by the Special Test.

The "Commercial Test" has been developed to effect this shortening of the actual testing procedure. This test gives data from which the operating characteristics of the motor may be determined accurately, without taking the time and accepting the delay and expense that would be incurred by making the complete series of observations comprised in the Special Test. This Commercial Test is therefore used for the greater number of induction motors built by the General Electric Company.

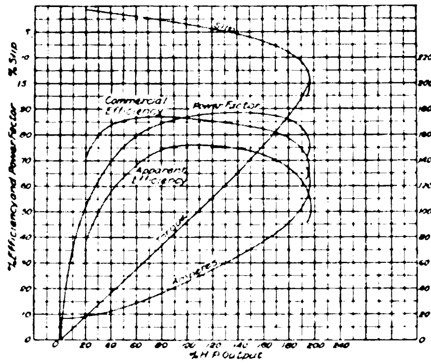


Fig. 2

Curves of Commercial Efficiency, Apparent Efficiency, Power Factor, Slip, Current, and Torque, for a 20 H.P. Induction Motor, Showing Maximum Output

Note that all of the curves turn back at the maximum output of approximately 39.5 h.p., giving two sets of values for each value of h.p. output between zero and the maximum. This condition means that for any torque above that giving maximum h.p. output the moter will tend to break, taking increasing current for decreasing speed, as shown by inspection of the amperes and slip curves.

As an illustration of the way in which the complete characteristics of the induction motor may be determined from a comparatively small number of check observations, the matter of the iron used in building a motor may be considered. If the quality of the iron laminations, or their insulation, were subject to much variation, complete tests would have to be made to determine for each individual motor all data dependent on the quality and insulation of the iron, such as hysteresis losses and eddy current losses, respectively. In a properly conducted factory, however, the magnetic quality of the laminations put into induction motors, and their insulation, are so uniform that the hysteresis and eddy current losses do not vary materially. This result is attained by imposing upon the iron manufacturer rigid specifications for the mixing and treatment of the iron; by systematic testing and inspection of all of the iron received, under a rigid standard which allows no iron having over a certain hysteresis loss per pound to be used; by a special annealing treatment at the General Electric factory; and by insulating the iron with a uniformly thin coat of a durable compound which will not have too large a coefficient of compression under heat and pressure, and which will maintain a fairly high resistance under these conditions.

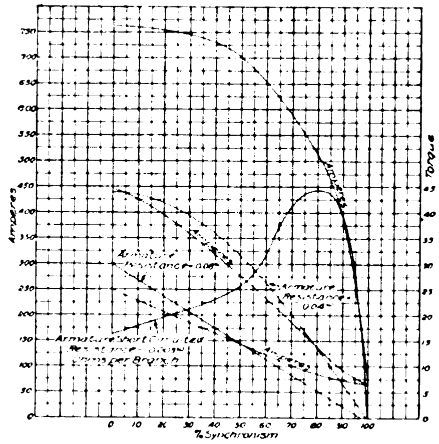


Fig. 3

Curves Showing Relation Between Torque and Speed, and Amperes and Speed, for a 30 H.P. Induction Motor, for Various Resistances in the Rotor Circuit

When the resistance of the armature circuit is of the critical value 0.04 ohm, the maximum torque (440 lb.) is given at starting.

When all starting resistance is cut out, the above maximum torque is attained at a speed of about 80 per cent of synchronism.

When the resistance of the rotor circuit is above the critical value 0.04 ohm, the maximum torque, which is the torque at starting, is reduced.

The quality of the copper put into the windings is also maintained at a constant and high standard, and is verified by preliminary measurements of the coils before they are finally connected in the machine.

Another feature of the manufacture which ensures uniformity of product is the interchangeability of parts, made possible by the fact that the detail dimensions of a motor of a given type and size are always the same. This interchangeability means a large initial outlay for dies, jigs, templates, gauges, and forms for coils, but secures the advantages of reduction in the first cost of the parts, and of saving of the time and expense required for fitting of parts in the assembly.

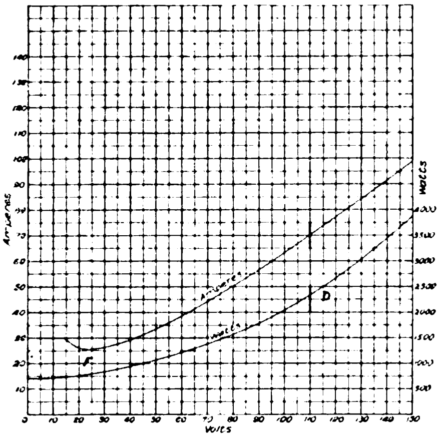


Fig. 4

Excitation Curves of a 30 H.P. 110 Volt Induction Motor, Showing the Values of Amperes and Watts Input for Various Voltages Applied, Beginning Above the Normal Running Voltage, for the Motor Running Light

In plotting the watts curve, due allowance is made for I^2R loss in the windings. As the voltage applied is reduced, a point is reached (at F) where the motor breaks down on the friction and windage load, which is therefore represented by the watts as read at the point F. The core loss equals the reading at D minus that at F.

Previous to the delivery of the motor to the Testing Department, it has been inspected for mechanical defects, and the windings measured for conductor resistance, and for insulation under high potentials several hundred per cent above the normal running voltage of the motor, the actual potential used depending on the running voltage and size of the machine.

When the motor is received for the Commercial Test, the resistance measurements are repeated, in order to detect any open circuits, and to give a complete, independent Testing Department record from which may be derived the copper losses at all loads. These tests serve also as a check on the proper quality of the copper and number of turns in the winding.

The air gap is measured with a thickness gauge, measurements being made at a large number of points about the periphery of the rotor, giving a check on the mechanical assembly of the field and rotor laminations.

An excitation test is then made by running the motor up to speed without a belt on the pulley, and reading the current input at normal voltage.

The motor is next belted to a machine of about the same size, and run for half an hour without load at 115 per cent. of normal voltage, observing the slip (see the accompanying illustration, Fig. 1), and making careful note of noise, imperfect balance of rotor, running out of true of parts, improper operation of oil rings, oil leaking or throwing, etc., and temperature of bearings, cores and windings at end of run. At the conclusion of this test the windings are subjected to another high potential breakdown test, under the American Institute of Electrical Engineers standard.

The excitation reading is then repeated. From the average of the two excitation readings a direct comparison can be made with exhaustive reports on similar machines, the various characteristics of which have been calculated from complete observations made in the course of the Special Test, as already described.

In the course of the Commercial Test, an open circuit in the rotor would become apparent by the motor failing to come up to speed, or failing to start at all. With a reversed phase, the motor will start but will not come up to full speed. Defective bearings will be indicated by the leaking of oil at the joints or around the oil gauge, by the throwing of oil, or by overheating of the bearings, as the case may be. When properly designed bearings are made in large numbers, and are interchangeable, the percentage of defective bearings is so low that cool bearings at the end of even a short run are a positive indication of the good condition of the bearings. If the bearing sleeve is not firmly clamped in the housing, the rotor will be very likely to strike the stator laminations. Bad joints or poorly soldered connections in a rotor will heat, increasing the rotor resistance, and will be detected in the impedance test, which is given just previous to painting: any increased resistance being indicated by lower than normal impedance current. This test also detects broken grids or poor connections in the starting resistance, reversed coils in the windings, crosses and short circuits. After painting, the high potential test under the American Institute of Electrical Engineers standard is again applied.

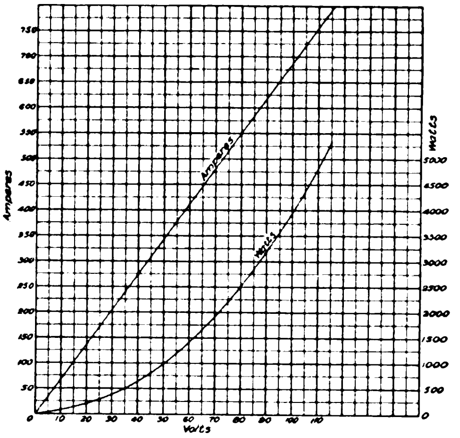


Fig. 5

Impedance Curves of a 30 H.P. Induction Motor, Showing Amperes and Watts at Various Voltages Taken by the Motor Standing Still (Rotor Blocked and Short Circuited)

The watts curve shows the sum of the I^2R losses of both rotor and stator. Of this sum the I^2R of the stator is calculated from the stator resistance, as measured, the rotor I^2R being the remainder.

To summarize: The Commercial Test has been developed with the primary object of detecting all of the defects to which an induction motor is liable. The mechanical features of the motors are as carefully noted in this test as in the most complete series of observations, so that the most important object of any commercial test—the detection and remedying of defects of manufacture—is fulfilled. On the other hand, since the various parts of these machines are interchangeable, and since the materials which enter into their construction are of uniform quality, there is no likelihood of any considerable variation in the electrical characteristics; while any variation that may occur is easily detected by the comparison of the excitation and impedance readings, and of the slip when running light, with the complete reports on similar machines that have been subjected to the Special Test.

EXPERIENCES WITH ELECTRIC COOKING DEVICES

To the Editor of the General Electric Company REVIEW:

Since writing the communication published in the April REVIEW, I have had our kitchen coal range removed and have therefore been absolutely dependent upon the electric devices for cooking and ironing. This step was taken for the following reasons:

The electric devices cost less to operate, are more cleanly, and give better results.

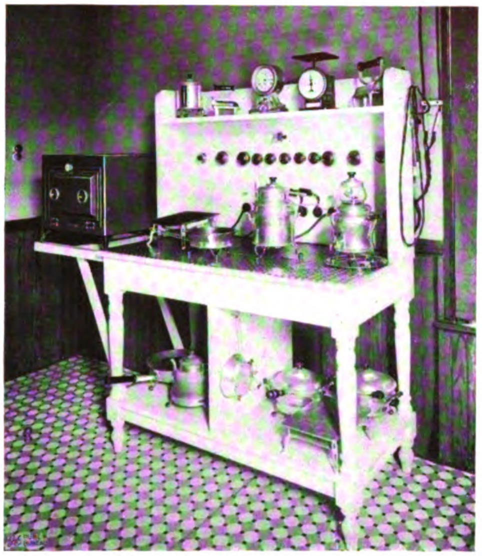
I wished to obtain data on the cost of operation of the electric devices under the condition of entire dependence upon these devices, so as to obtain a record the practical value of which would not be questioned.

With the coal range removed, the problem arose of finding a satisfactory method of obtaining an ample supply of hot water for laundry, bathing, dish washing, and general household purposes. I solved this problem satisfactorily by installing a gas heater, connected to the large kitchen tank. Since the installation of this heater, we have had available at any time ample quantities of boiling water, which has been used freely for the customary spring house cleaning, and for general household purposes.

Our bill for electricity for the month of April, not including current for lighting, which is metered separately, was $3.50, and our gas bill for the same period was $1.44, making a total of $4.94, covering the total cost of operation of the devices which supplanted the coal range. Comparing this amount with figures given in my former communication, above referred to, it will be seen that the combined cost of electricity and gas, notwithstanding the other advantages gained by the change, is less than the cost of operation of the coal range.

The annexed illustration, which shows our present kitchen outfit, may prove of interest to the reader in this connection.

I have frequently been asked if our electric oven gives as satisfactory results, and is just as quick in operation, as the coal range oven. In answer to the first part of this question, it is simply a repetition of the account in my former letter to say that the results are more satisfactory. In answer to the second point, I recently timed the cook in the preparation of a breakfast, consisting of steamed figs, cereal, chops, hot biscuit, and coffee, and can give the following figures: The cereal cooker, steamer, oven, and broiler were started simultaneously. In ten minutes the dough for the biscuits, which had been prepared meanwhile, was placed in the oven. By this time the broiler was hot and the chops were placed upon it, and the coffee percolator was started. In eighteen minutes more, a total of twenty-eight minutes from the time the breakfast was started, the entire meal was ready to serve.



Electric Kitchen Outfit in the Residence of Mr. M. O. Troy, Schenectady, N. Y.

The table is designed to give plenty of room for the devices, is lighted by an incandescent lamp, and has the oven conveniently located.

It is not amiss to say that a few explanations to the cook on the cost of operation of the devices will result in economies. I have explained the matter by telling her that it costs twice as much to operate the oven ten minutes as it does to operate it five minutes. Accordingly, she does not start the devices until five or ten minutes before she is ready to use them. On the other hand, she has found that when the biscuits, chops, etc., are about three quarters cooked, the current may be cut off, as the heat stored up in the devices is sufficient to complete the cooking.

M. O. Troy.

FIREPROOF QUALITIES OF THE GENERAL ELECTRIC FLAT IRONS

The following extract from a letter received from Mr. T. E. Bibbins, Manager of the Supply Department of the San Francisco Office, refers interestingly to the ruggedness of a lot of General Electric flat irons which passed through the San Francisco fire without serious injury:

> Oakland, Cal., May 17, 1906.
>
> Mr. H. W. Hillman,
> Supply Department,
> General Electric Co.,
> Schenectady, N. Y.
>
> Dear Sir:—
>
> I dropped you a line the other day written in pencil by me, to the effect that two irons taken out of the ashes of our warehouse were found to be all right electrically. Yesterday I sent you by express one 3-lb. flat iron which was taken from the same place; the wooden handle was destroyed and the iron is badly disfigured, but the iron as to utility is just as good as ever.

One of the Electric Flat Irons Taken from the Ruins of the General Electric Company's San Francisco Warehouse

The annexed illustration is reproduced from a photograph of the iron referred to. Mr. Bibbins goes on to say that he has no doubt that there are a large number of irons still in the ruins, in good operative condition, except, of course, for the burning of the wooden handles. He feels that this ordeal is a wonderful testimony to the indestructibility of the General Electric flat irons, and suggests that a number of these irons be distributed among the District Offices, believing that their exhibition as souvenirs ought to sell many other irons.

RECENT IMPORTANT SALES

New York Office

American Bridge Co., New York, N. Y.

For Sherzer Rolling Lift Bridge, Boston, Mass.

Two CO 2004-35 40 h.p. 500-600 volt series wound crane type motors.

Two solenoid brakes.

Two R-27 controllers.

Switchboard.

American Smelting & Refining Co.,
New York, N. Y.

For Utah Copper Co., Garfield, U.

Two ATB 72-1250-100-480 volt engine type generators.

Buffalo General Electric Co., Buffalo, N. Y.

One HC 8-500-375-280 volt rotary converter with induction regulator, step-down transformers and switchboard panels.

Cluett Peabody Co., Troy, N. Y.

The following 220 volt, three-phase induction motors:

One hundred and two form K motors ranging from 0.5 to 15 h.p. and aggregating about 312 h.p.

Four form L motors ranging from 5.5 to 75 h.p. and aggregating 136 h.p.

One 10 h.p. form M motor.

Consolidated Ry. Co., New Haven, Conn.

Five two-motor GE-87 (60 h.p.) equipments with K-6 controllers.

Derby Gas Co., Derby, Conn.

One ATB 4-500-1800-2300 volt 2-stage Curtis steam turbine.

One ATB 20-450-360-2300 volt 3-bearing belt driven generator.

One C 2-25-3600-125 volt Curtis turbine-exciter.

One CL 6-35-900-125 volt induction motor driven exciter.

O. M. Edwards, Syracuse, N. Y.

One ATB 26-70-276-220/125 volt generator, with direct connected exciter.

One switchboard.

Ten 220 volt, form K induction motors, aggregating 108.5 h.p., ranging from 1.5 h.p. to 25 h.p. inclusive.

Fonda, Johnstown & Gloversville R. R. Co.,
Gloversville, N. Y.

Four four-motor GE-73 equipments with Sprague-General Electric type M control.

Interborough Rapid Transit Co.,
New York, N. Y.

For installation in sub-station No. 21 (Brooklyn).

Forty-eight switchboard panels, for controlling four incoming lines and the following apparatus:

Four 1500 kw. 625 volt rotary converters.

Twelve 550 kw. 11,000-390 volt step-down transformers.

One 150 h.p. motor generator starting set with step-down transformers.

Four 12 h.p. D. C. blower motors.

One 35 h.p. air compressor motor.

One 55 cell, 15 amp.-hr. storage battery.

One motor generator charging set.

KEUFFEL & ESSER CO., HOBOKEN, N. J.

One MP 8-225-100-250 volt engine type generator.

NASHVILLE RY. & LIGHT CO., NASHVILLE, TENN.

Twelve GE-57 motors.

Six K-14 controllers.

Six circuit breakers.

NEW JERSEY & HUDSON RIVER RY. & FERRY CO., HACKENSACK, N. J.

Eight GE-90 (50 h.p.) four-motor equipments with K-14 controllers.

PUBLIC SERVICE CORPORATION OF NEW JERSEY, NEWARK N. J.

Sixteen GE-80 C motors.

ROCHESTER RY. & LIGHTING CO., ROCHESTER, N. Y.

One motor generator set, consisting of an ATB 18-530-400 volt generator direct connected to an MP 12-500-400-275 volt motor.

One switchboard.

SANDERSON & PORTER, NEW YORK, N. Y.

For New Orleans Ry. & Light Co., New Orleans, La.

Two 500 kw. motor generator sets, each consisting of an MP 8-500-514-550/600 volt generator driven by an ATB 14-530-514-6300 volt synchronous motor, with direct connected 22 kw., 125 volt exciter.

One 20-panel switchboard for the Claiborne Street sub-station, which is equipped with 500 kw. motor generator sets. A noticeable feature of the D.C. equipment is the use of electrically operated circuit breakers placed on pedestals near the individual machines.

UNION RY. CO., NEW YORK, N. Y.

Fifty two-motor GE-57 (50 h.p.) equipments with K-11 controllers.

UNITED GAS IMPROVEMENT CO., PHILADELPHIA, PA.

For Connecticut Ry. & Lighting Co., Greenwich, Conn.

Two AQB 12-200-600-2300 volt generators.

Two CE 5.5 kw. 1875 rev. per min., 125 volt exciters.

UTICA & MOHAWK VALLEY RY. CO., UTICA, N. Y.

Sixty GE-80 (40 h.p.) motors.

WATERTOWN ELECTRIC LIGHT & POWER CO., WATERTOWN, N. Y.

One magenitite arc lamp outfit, consisting of:

Six 50-light oil cooled constant current transformers.

Two hundred fifty magnetite lamps.

Six switchboard panels.

Boston Office

ATLANTIC SHORE LINE RY. CO., PORTSMOUTH, N. H.

Three four-motor GE-80 (40 h.p.) equipments with K-28 controllers.

BOSTON & NORTHERN STREET RY. CO., BOSTON, MASS.

Forty-one four-motor GE-90 (50-h.p.) equipments with Sprague-General Electric type M control, and forty-one straight air brake equipments with CP-21 compressors.

FALL RIVER ELECTRIC LIGHT CO., FALL RIVER, MASS.

Forty switchboard panels, for installation in the main generating station and sub-station.

KENNEBEC LIGHT & HEAT CO., AUGUSTA, ME.

Three ATB 12-200-600-2300 volt belted generators.

One CL 6-25-1100-125 volt exciter.

Five 100 amp. type CR feeder regulators for 10 per cent. regulations.

Two H 60-100-10000/2000 volt step-down transformers.

One 50-light and two 35-light air cooled constant current 6.6 amp. transformers.

Switchboard.

NATIONAL RY. CONSTRUCTION CO., BOSTON, MASS.

Six four-motor GE-80 (40 h.p.) equipments, with K-28 controllers.

STONE & WEBSTER, BOSTON, MASS.

For El Paso Electric Ry. Co., El Paso, Tex.

Two AQB 4-500-1800-2300 volt Curtis steam turbines.

For Houston Electric Co., Houston, Tex.

Ten four-motor GE-81 (30 h.p.) equipments, with K-28 controllers.

TABER MILLS, NEW BEDFORD, MASS.

One ATB 48-549-150-600 volt generator.

One CL-B 6-16-750-125 volt exciter.

Three I 12-150-600-550 volt form L induction motors.

Three H 60 transformers.

Generator and feeder panels.

UNITED SHOE MACHINERY CO., BEVERLY, MASS.

One ATB 6-1000-1200-2300 volt Curtis steam turbine-generator.

Chicago Office

ANACONDA COPPER MINING CO., ANACONDA, MONT.

Three I 32-600-225-2080 volt BD-3 induction motors.

One feeder panel.

Six 440 volt form K BD-3 induction motors, aggregating 805 h.p.

One I 4-5-1800-440 volt form K induction motor.

CENTRAL ILLINOIS CONSTRUCTION CO., PEORIA, ILLS.

Two ATB 4-2000-750-2300 volt Curtis steam turbine-generators.

Twenty-eight switchboard panels.

Lightning arresters.

Ten GE-73 four-motor car equipments, with Sprague-General Electric type M control.

One 50-ton electric locomotive, equipped with four GEA-16 (200 h.p) 25 cycle A.C. motors, complete, with Sprague-General Electric type M A.C. and D.C. control and straight and automatic air brake equipment.

Two 40-ton electric locomotives, each equipped with four GE-55 motors, with Sprague-General Electric type M controllers, and straight and automatic air brake equipment.

For Riverton, Ills.

Four four-motor car equipments with Sprague-General Electric type M control.

CHICAGO, BURLINGTON & QUINCY RY., CHICAGO, ILLS.

Three 25 kw. Curtis steam turbine-generators for train lighting.

CHICAGO & JOLIET STREET RY. CO., CHICAGO, ILLS.

Nine four-motor (40 h.p.) equipments with K-28 controllers.

Five straight air brake equipments with CP-22 (24 ft.) compressor.

CHICAGO & MILWAUKEE ELECTRIC RY. CO., HIGHWOOD, ILLS.

Three AB 25-185 kw. 13200-430 volt transformers.

East St. Louis & Suburban Ry. Co., East St. Louis, Ills.

One 1000 kw. 60 cycle 2300 volt three-phase, low pressure Curtis steam turbine-generator.

Hutchinson Interurban Ry. Co., Hutchinson, Kas.

Four two-motor GE-54 equipments, with K-10 controllers.

Kansas City Western Ry. Co., Kansas City, Mo.

One 200 kw. rotary converter, with transformers and reactive coils.

Five switchboard panels.

Lightning arresters.

Kansas City & Westport Belt Ry. Co., Kansas City, Mo.

One HC 10-750-300-600 volt compound wound rotary converter.

Three AB 275 kw. 6600/420 volt 25 cycle transformers.

One 8-panel switchboard.

Fifty-five cells chloride accumulator, with panel.

Lightning arresters.

One 50-ton D.C. electric locomotive, equipped with four GE-55 motors, with Sprague-General Electric type M control.

Lincoln Traction Co., Lincoln, Neb.

Eight two-motor GE-54 equipments, with K-10 controllers.

Madison & Interurban Ry. Co., Madison, Wis.

Eight two-motor GE-67 equipments, with K-10 controllers.

Milwaukee Electric Ry. & Light Co., Milwaukee, Wis.

Two AB 25-1000-13200-33000 volt three-phase-two-phase transformers.

Four OC 25-300 kw. 33000-3300 volt single-phase step-down transformers.

Switchboard.

The above apparatus is for the two new interurban single-phase lines of the Milwaukee electric railway system, which were described in an article in the April number of the Review.

National Ry. Construction Co., West Superior, Wis.

For the Great Northern Power Company's substation in the Superior Water & Light Company's plant at West Superior, Wis.

One 8-panel switchboard.

Northwestern Elevated Ry. Co., Chicago, Ills.

One HC 16-2000-188-600 volt compound wound rotary converter, with necessary appurtenances, including

Three AB 25-750-9000-430 volt single-phase air blast step-down transformers.

Four switchboard panels.

Omaha & Council Bluffs Street Ry. Co., Omaha, Nebr.

Twenty two-motor GE-80 (40 h.p.) equipments with K-10 controllers, making a total of forty-five equipments of this type ordered.

Rockford Edison Co., Rockford, Ills.

Two 500 kw. 2300 volt three-phase Curtis turbine-generators.

Shawnee Light & Power Co., Shawnee, Okla.

One motor generator set, consisting of an MP 4-300-720-575 volt compound wound generator direct connected to an ATB 10-325-720-2300 volt synchronous motor.

Southern Michigan Ry. Co., Kalamazoo, Mich.

Six four-motor GE-74 (65 h.p.) equipments with Sprague-General Electric type M control, similar to ten equipments now in operation.

Southwest Missouri Electric Ry. Co., Webb City, Mo.

Eight straight air brake equipments, for double end operation.

Terre Haute Traction & Light Co., Terre Haute, Ind.

One motor generator set consisting of an MP 8-500-514-600 volt generator direct connected to an AQB 14-530-514-2300 volt synchronous motor. This motor generator set is a duplicate of one now in operation by this Company.

Topeka Ry. Co., Topeka, Kas.

Four two-motor GE-80 equipments with K-11 controllers.

Twin City Rapid Transit Co., Minneapolis, Minn.

Two HC 35-1500-260-600 volt rotary converters with necessary appurtenances, including

Six AB 35-530-12500-426 volt single-phase step-down transformers.

Six switchboard panels.

Fifty-four four-motor GE-70 equipments with K-28 controllers.

Fifty four-motor GE-70 equipments with K-28 controllers.

United Railways Co. of St. Louis, St. Louis, Mo.

Two type HC 8-1000-375-600 volt rotary converters, with necessary appurtenances, including

Two ABH 25-1100-6600 volt transformers.

Waterloo, Cedar Falls & Northern Ry. Co., Waterloo, Ia.

Two four-motor GE-80 equipments with K-28 controllers.

Philadelphia Office

Altoona & Logan Valley Ry. Co., Altoona, Pa.

Twenty-two two-motor GE-80 (40 h.p.) equipments with K-10 controllers.

Atlantic City Construction Co., Atlantic City, N. J.

Two TC 6-300-500-600 volt, 25 cycle rotary converters, with transformers, switchboard and accessories.

Baltimore & Ohio Co., Baltimore, Md.

Two HC 8-500-375-240 volt rotary converters, with appurtenances and switchboard.

Charlotte Consolidated Construction Co., Charlotte, N. C.

Two ATB 60-540-120-125 volt.

One engine driven exciter.

One motor generator set, consisting of a CL-B 6-40-720-125 volt D.C. generator direct connected to an I 10-60-720-2300 volt form K motor.

Consolidated Gas, Electric Light & Power Co., Baltimore, Md.

Forty type IRS automatic clutch operated regulators, aggregating 672 kw.

Easton & Washington Traction Co., Easton, Pa.

Five four-motor GE-80 (40 h.p.) equipments, with K-28 controllers.

Edison Electric Ill'g Co., Cumberland, Md.

One ATB 4-500-1800-2300 volt Curtis steam turbine-generator.

One C 2-25-3600-125 volt 150 lb. non-condensing Curtis steam turbine-exciter.

One HC 8-300-900-550/600 volt compound wound rotary converter, with appurtenances and switchboard.

Electric Construction Co. of Virginia,
Richmond, Va.

For Martinsville, Va.

Twenty-six thousand, five hundred and twenty-five lb. of T. B. W. P. wire in sizes 1, 2, 6 and 8 B. & S. gauge.

Fairmont & Clarksburg Traction Co.,
Fairmont, W. Va.

Six air brake equipments with CP-22 (24 ft.) compressors for double end operation.

H. C. Frick Coke Co., Pittsburg, Pa.

For Fairchance, York Run and Wynn, Pa.

Three 20-ton tandem locomotives, each consisting of two LM-104 C-2 machines.

Heyl & Patterson, Incorporated, Pittsburg, Pa.

Two CL-B 8-205-410-220 volt compound wound motors.

Three CL-B 6-150-450-500 volt compound wound motors.

Norfolk & Portsmouth Traction Co.,
Norfolk, Va.

Three ATB 10-3000-720-11000 volt Curtis steam turbine-generators.

One ATB 8-1500-900-1000 volt Curtis steam turbine-generators.

Two C 4-75-2400-125 volt non-condensing Curtis steam turbine-generators.

Six HC 12-500-600-575 volt compound wound rotary converters, with step-down transformers.

Three HC 8-300-900-575 volt rotary converters, with step-down transformers.

Norfolk & Southern Rapid Transit Co.,
Norfolk, Va.

One HC 6-500-500-600 volt, 25 cycle, rotary converter.

One TC 6-300-500-600 volt, 25 cycle, rotary converter.

Transformers, switchboards and accessories.

Philadelphia Rapid Transit Co.,
Philadelphia, Pa.

One hundred four-motor GE-80 equipments, with K-28 B controllers.

Richmond & Chesapeake Bay Ry. Co.,
Richmond, Va.

The General Electric Company has recently secured the contract for generating apparatus and single-phase car equipments constituting the initial installation of a line which is now being built from Richmond to Ashland, a distance of 15 miles, and which will eventually extend to Chesapeake Bay, a total distance of 150 miles. This order includes:

One two-unit generating set consisting of a 750 kw., 6600 volt, 25 cycle, three-phase generator, direct connected to a 750 kw., 2300 volt, 60 cycle, three-phase generator.

One two-unit generating set consisting of a 750 kw., 6600 volt, 25 cycle, three-phase generator, direct connected to a 750 kw., 550 volt,, D.C. generator.

One 100 kw. motor generator set consisting of a 100 kw., 2300 volt, 60 cycle, three-phase generator, direct connected to a 150 h.p., 440 volt, 25 cycle, single-phase, induction motor.

One 150 kw., 25 cycle, oil cooled step-down transformer for above set.

Necessary switchboard equipment.

Four four-motor GEA-603 (125 h.p.) A.C. equipments complete with Sprague-General Electric type M control.

Four combined straight and automatic air brake equipments with CPA-52 compressors.

The two-unit generating sets will be installed in the Richmond station of the Virginia Passenger & Power Co., each set being connected to a water wheel of sufficient capacity to drive both machines of the set at their full regular capacity. These generators will normally be driven by water power: the 25 cycle machines furnishing current for the Richmond & Chesapeake Bay line, and the 60 cycle and D.C. machines supplying current to the Virginia Passenger & Power Co., and operating in parallel with machines now in service. In case of insufficient water supply, the 25 cycle generators will be driven by the 60 cycle generator and D.C. generator acting as motors and supplied with current from the engine driven units in the same station.

The 25 cycle generators will for the present be operated single-phase, supplying current directly to the trolley line at 6600 volts.

The line construction will be of the catenary type, insulated for 6600 volt operation.

The 100 kw. motor generator set will be installed at Ashland to furnish current for the local lighting system, operating current being taken from the single-phase trolley line.

This road will practically parallel the Richmond, Frederick & Potomac Ry. from Richmond to Ashland, and it is intended to maintain a fast schedule between these points, operating cars at frequent intervals.

Scranton Ry. Co., Scranton, Pa.

Twenty-five four-motor GE-80 (40 h.p.) equipments, with K-28 controllers.

Ten two-motor GE-80 equipments, with K-10 controllers.

Thirty straight air brake equipments, with CP-22 (24 ft.) compressors.

Wilmington City Ry. Co., Wilmington, Del.

One MP 10-600-100-575 volt generator.

One MP 14-800-100-575 volt generator.

Switchboard panels.

Clemson Agricultural College,
Clemson College, S. C.

Laboratory apparatus consisting of:

One MP 6-75-225-125/250 volt compound wound three-wire generator, with compensator for derived neutral.

One ATB 26-70-276-2300 volt generator, with direct connected exciter.

One TC 6-75-1200-250 volt three-wire rotary converter, with starting panel, reactive coil and transformers.

One TA-125 form A-2 regulator.

One switchboard for the control of this apparatus, consisting of one panel, one three-wire D.C. rotary converter panel, one A.C. rotary converter panel, one three-phase A.C. generator panel, and one A.C. feeder panel.

The order for the above apparatus was secured in the face of very keen competition. The installation will make one of the best college plants in the country, maintaining at the same time an excellent advertisement for the General Electric Company. This college is already equipped with a number of up-to-date General Electric machines, transformers, switchboard panels, and instruments.

Atlanta Office

Anderson Traction Co., Anderson, S. C.

One three unit 550 kw. motor generator set consisting of an IQ 10-600-800-1150 volt two-phase 66 2/3 cycle induction motor direct connected to one ASB 4-300-800-3300 volt, 25 cycle, single-phase generator.

One MP 4-250-800-600 volt direct current railway generator with direct connected MP 6-8-800-125 volt exciter.

Complete A.C. and D.C. switchboard for the above motor generator set.

Three four-motor GEA-605 (75 h.p.) single-phase car equipments with A.C.-D.C. hand control.

Three straight air brake equipments with CPA-52 compressors for A.C.-D.C. operation.

Georgia Ry. & Electric Co., Atlanta, Ga.

One HC 6-500-600 volt, 25 cycle, compound wound rotary converter, with transformers, switchboard and accessories.

Cincinnati Office

Canton Light, Heat & Power Co., Canton, O.

One ATB 4-500-1800-2300 volt Curtis steam turbine-generator.

Cleveland Crane & Car Co., Cleveland, O.

Fifteen CQ 220 volt motors.

Cleveland Worsted Mills Co., Cleveland, O.

One 9-panel switchboard.

Seven H 60-150-2300-240 volt transformers.

Cleveland Electric Illuminating Co.,
Cleveland, O.

One hundred type I meters

Forty-six type H transformers, aggregating 550 kw.

Columbus Ry. & Light Co., Columbus, O.

Two CP-21 straight air brake equipments.

Ten extra MC compressor governors.

Ten two-motor GE-67 (40 h.p.) equipments, with Sprague-General Electric type M control. similar to the equipments already in operation.

One partial four-motor GE-67 equipment, with K-6 controllers.

One hundred and sixty type I meters.

Cincinnati Gas & Electric Co., Cincinnati, O.

Twenty-five thousand lb. T. B. W. P. wire.

Day, J. H., Cincinnati, O.

Three 220 volt two-phase induction motors, aggregating 13 h.p.

Twelve 115, 220, 230 and 500 volt CA motors, aggregating 36.5 h.p.

Morgan Engineering Co., Alliance, O.

One hundred and five 220 volt 3-circuit crane panels, aggregating 6650 h.p.

Ninety 220 volt 4-circuit crane panels, aggregating 9200 h.p.

Twenty 220 volt 5-circuit crane panels, aggregating 2675 h.p.

Denver Office

Canon City, Florence & Royal Gorge Interurban
Ry. Co., Canon City, Colo.

Five four-motor GE-57 equipments with K-14 controllers.

Colorado Springs Electric Co.,
Colorado Springs, Colo.

One WC 60-250-6200/460 volt transformer.

Dept. of the Interior, United States Geological
Survey, Lujane, Colo.

For United States Reclamation Service.

One CL-B 6-75 kw. 850-250 volt generator.

Mill Creek Power Co., Salt Lake City, U.

For Mill Creek, U.

Three WC 60-100-16100/14950/13800-2300/4000 volt transformers.

Three WC 60-100-16100-14950/13800-230 volt transformers.

L. L. Nunn, Provo, U.

One ATB 32-3600-225-11000 volt generator for water wheel drive.

One CL-B 6-75-600-125 volt exciter.

Four WC 60-1000-2500/5000-20000/40000 volt transformers.

Forty-three type H transformers, aggregating 845 kw.

Pueblo & Suburban Traction & Lighting Co.,
Pueblo, Colo.

One ATB 30-800/960-120-2300 volt 30 cycle engine type generator.

Raton Electric Light & Power Co., Raton, N. M.

One ATB 8-100-900-2300 volt generator, with switchboard panel.

Utah Light & Ry. Co., Salt Lake City, U.

One IRT 4-150-60-2300/4000-340/600-290/145 volt water cooled regulator.

Sales have also been made covering the following motors:

Twenty-five A.C. motors, aggregating 235 h.p.

Twelve D.C. motors, aggregating 280 h.p.

Small Motor Department

Chicago Edison Co., Chicago, Ills.

Twenty-four motors, aggregating 111 h.p.

Enterprise Mfg. Co., Philadelphia, Pa.

Twenty-three CQ motors, aggregating 60 h.p.

Henion & Hubbell, Chicago, Ills.

Seven CQ motors, aggregating 32 h.p.

Lansden Co., Newark, N. J.

Twenty-five GE-1011 85 volt 30 amp. automobile motors.

Ransome Concrete Machinery Co.,
New York, N. Y.

Six CQ motors, aggregating 60 h.p.

Tholen Brothers, Leavenworth, Kas.

Nineteen CQ motors, aggregating about 25 h.p.

Wheeler-Green Electric Co., Rochester, N. Y.

Nine CQ motors, aggregating 51.5 h.p.

Foreign Department

Australian General Electric Co.,
Melbourne, Aus.

For Wellington Tramways, Wellington, New Zealand.

Eight two-motor GE-67 railway equipments, with B-18 controllers.

Bagnall & Hilles, Yokohama, Japan.

For Keihin Traction Co., Keihin, Japan.

Five four-motor GE-67 railway equipments.

For Kiriu Water Power Co., Kiriu, Japan.

One ATB 16-350-450-6600 volt water wheel driven generator complete, with six 75 kw. step-down transformers, 15 MR regulators and necessary switchboard panels.

Canadian General Electric Co., Toronto, Ont.

For Pittsburg Reduction Co., Pittsburg, Pa.

Six MP 14-2100-225-700 volt, D.C. generators. These generators will be coupled in pairs to 6000 h.p. water wheels and installed in the new factory which the Pittsburg Reduction Company proposes to build at Shawinigan Falls, Canada.

French Thomson-Houston Co., Paris, France.

Two ATB 8-3000-750-5500 volt, three-phase Curtis steam turbine-generator sets.

Twenty two-motor (two 50 h.p.) Sprague-General Electric type M control equipments (motors to be built by Ateliers Thomson-Houston, Paris).

W. R. Grace & Co., New York, N. Y.

For Santiago & San Bernards, Santiago, Chili.

Three CL-B 6-100-600-500 volt railway generators.

Six four-motor GE-80 railway equipments.

For Lima-Callao Ry., Lima, Peru.

One HC 8-300-900-600 volt, rotary converter, with OCH 60-330-10000-430 volt transformer.

Kolar Gold Fields, Kolar, India.

Three motor generator sets, each consisting of

One ATB 8-400-375-3300 volt, three-phase generator, direct connected to an MP 6-575 h.p. 375-500/550 volt D.C. motor.

Two motor generator sets, each consisting of a CL-B 6-125-375-500/550 volt generator, direct connected to an ATB 8-135-375-2200 volt synchronous motor.

Mexican General Electric Co., Mexico City, Mex.

For Ferrocarril Electrico de Lerdo a Torreon, Gomez Palacio, Durango, Mexico.

One AQB 12-200-550-2300 volt two-phase generator.

Mitsui & Co., Tokio, Japan.

For Hiroshima Power Co., Hiroshima, Japan.

One ATB 36-240-200-2300 volt generator complete, with exciter and switchboard panels.

Sussdorf, Zaldo & Co., Havana, Cuba.

For Santiago Lighting Co., Santiago, Cuba.

One ATB 4-500-1800-2300 volt Curtis steam turbine-generator.

One MP. 6-10-450-110 volt engine driven exciter.

SALES OF INDUCTION REGULATORS

The following sales of induction regulators were made in the first three months of the present fiscal year. These orders aggregate a large increase, in the number of induction regulators sold, over last year's business, and show that good feeder regulation is being more widely appreciated.

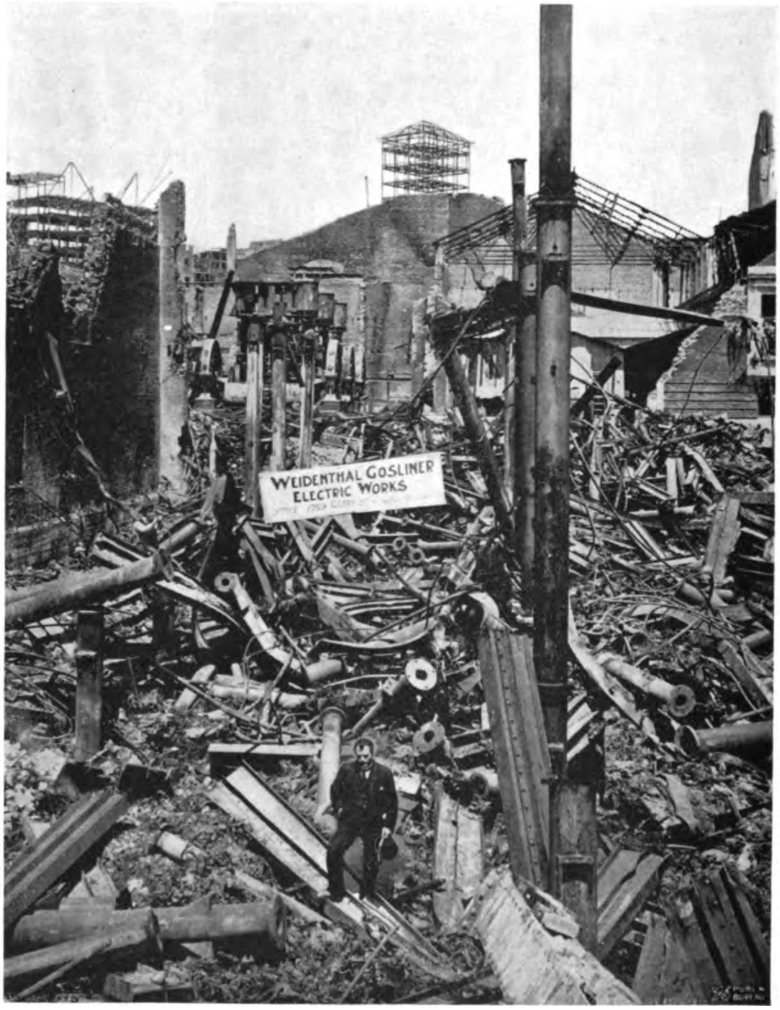
Purchaser	Number of Regulators Sold	Rating	Method of Operation
Chicago Edison Co., Chicago, Ills.	9	IRS 2- 24 -60	Motor
	2	IRH 4- 44 -25	Motor
	25	IRS 2- 18 -60	Motor
Cleveland Electric Ill'g Co., Cleveland, O.	40	IRS 2- 7½-60	Motor
	1	IRT 4- 9 -60	Automatic
Columbus Ry. & Light Co., Columbus, O.	18	IRS 2- 11 -60	Motor
Commonwealth Power Co., Jackson, Mich.	6	IRS 2- 11½-60	Hand
Consolidated Gas, Light & Power Co., Baltimore, Md.	1	IRS 2- 22 -60	Automatic
	12	IRS 2- 24 -60	Automatic
Detroit Edison Co., Detroit, Mich.	10	IRS 2- 25 -60	Motor
	4	IRT 4- 76 -60	Motor
Edison Electric Ill'g Co., Boston, Mass.	1	IRS 2- 23 -60	Hand
French Thomson-Houston Co., Paris, France	2	IRT 4- 19 -25	Hand
Hudson River Electric Co., Albany, N. Y.	2	IRS 2- 38 -40	Automatic
Nashville Ry. & Light Co., Nashville, Tenn.	2	IRH 4-120 -60	Motor
Oakland Gas & Light Co., Oakland, Cal.	3	IRT 4- 50 -60	Automatic
Omaha Electric Light & Power Co., Omaha, Nebr.	1	IRS 2- 33 -60	Motor
Philadelphia Electric Co., Philadelphia, Pa.	12	IRS 2- 16½-60	Automatic
Potomac Electric Co., Washington, D. C.	5	IRS 2- 12½-60	Automatic
Public Service Corporation of New Jersey, Camden, N. J.	14	IRS 2- 11½-60	Hand
San Francisco Gas & Light Co., San Francisco, Cal.	6	IRS 2- 46 -60	Hand
Stamford Gas & Electric Co., Stamford, Conn.	1	IRS 2- 16½-60	Automatic
Syracuse Light Co., Syracuse, N. Y.	1	IRS 2- 10 -60	Automatic
Union Electric Light Co., St. Louis, Mo.	1	IRS 2- 22 -60	Automatic
Utah Light & Ry Co., Salt Lake City, U.	1	IRT 4-150 -60	Automatic
H. C. Wirt Mfg. Co., Hanson, Mass.	1	IRS 4-150 -60	Hand

AN ENTERPRISING MOTOR AGENCY

One of the most successful Motor Agencies of the General Electric Company is held by the Weidenthal-Gosliner Electric Works, of San Francisco. Previous to the recent disaster, this agency occupied commodious premises near the station of the San Francisco Gas & Electric Company. The earthquake and fire completely devastated the shop and salesroom of the agency, reducing the strongly built structure in which they were located to a complete wreck, as shown in the annexed illustration, which is reproduced from a photograph kindly forwarded by Mr. F. F. Barbour, Manager of the General Electric Company's San Francisco Sales Department.

Notwithstanding the destruction of its place of business, together with the stock, tools and all other material accessories, the agency did not go out of business for an hour. Mr. Weidenthal, who is shown standing on the ruins of his shop in the foreground of the picture, immediately made arrangements for continuing the business with increased activity; and having saved its books and accounts the agency has been able to take full advantages of opportunities offered, and has sold motors faster than the Factory could supply them. Mr. Barbour calls attention to the fact that Mr. Weidenthal's picture does not look like that of a man who is very much dejected. It will be noticed that he has his rule in his hand, and is without doubt engaged in planning for larger quarters and facilities, more adequate to the increased business which has come to his company since the disaster.

It is interesting to note the view of a portion of the San Francisco Gas & Electric Company's station which may be seen in the background of the picture through the wreck of the Weidenthal-Gosliner building.



Ruins of a General Electric Company Motor Agency, San Francisco

When one carefully examines the whole photograph and notes the thickness of the heavy walls, the strength of the steel framing and the generally massive construction of the buildings, it is not difficult to understand, in a measure, at least, the terrific destructive power of earthquake and fire which so recently visited the City by the Golden Gate.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

The Electric Automobile.

[Elec. Age, March, 1906, p. 161]

An historical account of the development of electric automobiles, with many illustrations of the various types of machines built since 1895. Due credit is given to General Electric equipments.

The Lighting of Streets.

[Elec. Wld., May 19, 1906, p. 1038]

Abstracts of the papers read at the May meeting of the Illuminating Engineering Society. Mr. F. W. Willcox's paper proposed the use of General Electric high efficiency graphitized filament lamps, supplied from constant current transformers.

100 Ton Electric Derrick Crane at Scotts' Dock, Greenock.

[Engng., April 27, 1906, p. 554]

An illustrated description of a derrick crane having a capacity of 100 tons at any radius between 25 ft. and 70 ft., and a capacity of 860 tons at a radius of 90 ft., and equipped with an independent light purchase gear which is capable of lifting 10 tons at any radius up to 100 ft. The maximum load is raised at the rate of 5 ft. per min., loads under 50 tons at 10 ft. per min., and loads under 10 tons at 40 ft. per min. Four British Thomson-Houston Co. motors are provided for operating the crane, viz: two 50 b. h. p. motors for derricking the jib and for main purchase hoisting, and two 35 b. h. p. motors for light purchase hoisting and for slewing.

Electrical and Mechanical Equipment of the New Engineers' Club Building, New York.

[Elec. Wld., May 10, 1906, p. 1031]

An illustrated description of the new club house which is now under construction on West Fortieth Street. A plan is given of the sub-basement, which contains the electric power plant comprising two 50 kw., 125 rev. per min., 245 volt engine driven generators, and one 75 kw., 2400 rev. per min., 245 volt Curtis steam turbine-generator to be donated by the General Electric Company. The plan affords an excellent comparison of the space economy effected by the installation of the Curtis steam turbine-generators as compared with engine driven generators.

Features of Engineering Interest in a Large Cold Storage Plant.

[W. Elec'n., May 26, 1906, p. 413]

The North American Cold Storage Company's cold storage warehouse at Chicago comprises a basement power plant with one 150 kw. and one 250 kw., 250 volt engine driven Northern Electric Mfg. Company D. C. generator to supply the electrically driven pumps, compressors, elevators, etc. Illustrations of the power plant and of the refrigerating plant are given.

The New Steam Plant for the Pacific Light & Power Co., Los Angeles.

[Eng. Rec., Apr. 28, 1906, p. 55]

A brief description of the new plant to be erected at Redondo, a suburb of Los Angeles. The equipment is to include three 5000 kw., 18,000 volt, 50 cycle, engine driven flywheel type General Electric three-phase generators.

The Boston Edison Company's Natick Station.

[Elec. Wld., April 28, 1906, p. 874]

An interesting illustrated note relative to the change of an old belt driven steam plant into a transformer sub-station equipped with 900 kw. 6500-2300 volt transformers, four 50-light constant current transformers, and the necessary switchboard, all of General Electric make.

The Betterment of Power Station Economy by Electric Auxiliaries.

[Eng. Mag., April, 1906, p. 87]

The author, Mr. A. S. Mann, points to the advantages of electrically driven auxiliaries supplied from the low pressure stages of the steam turbine, compared with steam driven auxiliaries supplied with high pressure steam and exhausting into the feed water heater system. The service in the new power house at the General Electric Company's Schenectady Works, which is equipped with Curtis steam turbine-generators of 10,000 kw. aggregate output, requires twenty-nine auxiliary machines, including two exciters, of capacities ranging from 5 h. p. to 60 h. p. An aggregate of 445 h. p. is saved by employing electrically driven auxiliaries, using all of the high pressure steam in the turbines to generate current, and using some of the low pressure steam for heating the feed water to the same temperature which would be obtained by the exhaust of the low economy auxiliary engines, instead of taking a portion of the high pressure steam to supply steam driven auxiliaries. Furthermore, the twenty-nine electrically driven units, scattered over various parts of the plant, are taken care of by one man.

Japanese Steam Turbine Electric Station.

[Elec. Wld., May 12, 1906, p. 983]

A brief description of the development of the Osaka Electric Light Co., which was organized in 1888 with a capital of about $200,000 but now has a capital of nearly $1,500,000. The population of Osaka is about 1,000,000, including Sakan, a suburb. The four power stations are equipped with Curtis steam turbine-generators and engine driven generators of General Electric make, including one 1000 kw. and four 500 kw., 2300 volt, 60 cycle units, and another 1000 kw. Curtis steam turbine-generator has been ordered for a projected new station which is designed for a load of 300,000 16 c. p. lamps. Illustrations of the Honden station, containing two 500 kw. Curtis steam turbine-generators, are also given.

The Hydro-Electric Development at Trenton Falls, N. Y.

[Elec. Wld., May 19, 1906, p. 1027]

The 8000 h. p. water power development of the Utica Gas & Electric Co., at Trenton Falls, N. Y., utilizes the power of West Canada Creek, and is equipped with General Electric machines and switchboards. There are installed four 2000 h. p., 360 rev. per min. Fourneyron water turbine driven, 2300 volt, 50 cycle, vertical shaft, three-phase alternators, and two 100 h. p., 750 rev. per min., 125 volt, vertical shaft, water wheel driven D. C. generators. The line potential is 23,000 volts. It is contemplated to enlarge the plant at once to a capacity of 16,000 h. p., and to develop two other near-by water powers, of 6500 h. p. and 3000 h. p., respectively, which will swell the aggregate capacity of the water wheel driven generators to 25,000 h. p. A number of drawings and photographs show details of the plant.

Hydraulic Features of the Plant of the Pike's Peak Hydro-Electric Co., Manitou, Colo.

[Eng. Rec., May 19, 1906, p 621]

This station is of special interest for the reason that it operates under a static head of 2417 ft. The discharge is into a storage reservoir from which the water works system of Colorado Springs is supplied. Three of the ultimate equipment of four 750 kw., 450 rev. per min. Pelton water wheel driven exciters have been installed thus far, together with the necessary controlling and distributing switchboards.

Washington Water Power Company's System and New Equipments.

[St. Ry. Jour., May 26, 1906, p. 825]

An illustrated description of the twenty-one cars ordered by the above Company for the Spokane railway systems. The cars are equipped with four 75 h. p. motors and Sprague-General Electric Type M control.

Electrification of The West Shore Railroad between Utica and Syracuse.

[St. Ry. Jour., May 19, 1906, p. 787]

A brief but interesting account giving data and a map of the above 120 mile road. Three-phase current will be supplied at 60,000 volts by the Hudson River Electric Power Co. and will be converted into 600-volt D. C. in four substations, each equipped with two 300 kw. rotary converters. The rolling stock is to comprise fifteen 50 ft. motor cars with four-motor GE-73 equipments and Sprague-General Electric Type M control.

The St. Francois County Electric Railway.

[St. Ry. Jour., May 26, 1906 p. 812]

An illustrated description of the 11.5 mile road connecting Farrington, Mo., with three adjacent steam roads. The rolling stock is equipped with GE-70 and GE-57 motors.

New Electric Trains on the Metropolitan Railway

[Elec'n, London, June 1, 1906, p. 248]

An illustrated description of the new six car trains for this road, composed of four trailers and two motor cars. Each motor car is equipped with four GE-69 (200 h.p.) motors, Sprague-Thomson-Houston electromagnetic multiple unit control and a CP-22 air compressor.

Magnetite Deposits and Mining at Mineville, N. Y.

[Eng. & Mining Jour., June 9, 1906, p. 1082]

An illustrated description of the separating plants, which are equipped with General Electric 440 volt, 25 cycle, three-phase induction motors of capacities ranging between 10 h.p. and 100 h.p.

The New Shops of the Canada Car Company, Ltd., at Montreal.

[R. R. Gaz., June 8, 1906, p. 584]

These shops, which are located on a fifty acre tract of land and occupy a floor area of a little over seven acres, have at present a capacity of twenty freight cars a day and ten passenger cars a month. The power house equipment described and illustrated in this account includes two 500 kw., 600 volt, 60 cycle, three-phase Curtis steam turbine-generators, a 25 kw. Curtis steam turbine-exciter, a 30 kw. motor generator exciter, and a large switchboard. Electric power is distributed for operating the various tools, and a table accompanies the article setting forth the h.p. of the motors and the various methods of drive used: belt, gear, chain, and direct.

Atlantic City Convention of National Electric Light Association

[Supplement to Elec. Wld., June 9, 1906]

This report includes abstracts of the following interesting papers on General Electric apparatus and machinery.

THE MERCURY ARC RECTIFIER FOR STREET ILLUMINATION, page 1215:

Reports the increase in all-round efficiency of the Portland, Ore., street lighting system obtained by installing twelve hundred magnetite arc lamps fed by General Electric mercury arc rectifiers in place of an installation of 500 watt open arc lamps fed by induction motor driven arc machines.

PRESENT STATUS OF THE STEAM TURBINE, p. 1217:

This paper sets forth the number of steam turbine-generators, of various manufacturers, that are installed, under construction or on order at the present time. The following tabulation of data given in the paper shows the predominance of the General Electric Company in this field:

MANUFACTURERS	No. of Units	Aggregate Kw. Capacity
General Electric Co....	592	580,325
Two Chief Competitors	291	351,520
Totals	883	931,845

AUTOMATIC SWITCHBOARD DEVICES, p. 1228:

A brief account of the automatic switchboard devices employed in four representative A.C. distribution systems installed to serve communities of various sizes ranging from a small village up to a very large city.

THE REPORT ALSO INCLUDES AN ACCOUNT OF THE GENERAL ELECTRIC COMPANY'S EXHIBIT, p. 1234.

Meeting of the American Institute of Electrical Engineers

[St. Ry. Jour., June 9, 1906, p. 917]

Abstracts of the papers which were presented, including Mr. D. B. Rushmore's contribution entitled "Electrical Connections for Power Stations."

General Electric Company Review, June, 1906

INDEX

Page
Abstracts of Important Technical Articles.................. 33
American Institute of Electrical Engineers, Meeting of the 34
Automobile, Electric, The.................................. 33
Exhibit at Atlantic City, General Electric Company's.... 34

Generating Systems:
  Boston Edison Company's Natick Station, The........ 33
  Cold Storage Plant, Features of Engineering Interest in a Large.. 33
  Equipment, Electrical and Mechanical, of the New Engineers' Club Building, New York............... 33
  Pike's Peak Hydro-Electric Co., Manitou, Colo., Hydraulic Features of the Plant of the................. 34
  Pacific Light & Power Co., Los Angeles, The New Steam Plant for the.................................. 33
  (See also "Motor Drive" "Transmission.")

Heating Devices, Electric:
  Cooking Devices, Experiences with Electric, by M. O. Troy 24
  Flat Irons, Fireproof Qualities of the General Electric 26

Illumination:
  Streets, The Lighting of.............................. 33
  Street Illumination, The Mercury Arc Rectifier for.... 34

Magnetite Deposits and Mining at Mineville, N. Y. 34
Motor Agency, An Enterprising........................... 32

Motor Drive:
  Auxiliaries, Electric, The Betterment of Power Station Economy by...................................... 33
  Crane, 100 Ton Electric Derrick, at Scotts' Dock, Greenock 33
  Shops of the Canada Car Co., Ltd., The New, at Montreal 34
  (See also "Generating Systems and "Motors.")

Motors:
  Induction Motors, Commercial Test of, by E. B. Raymond 20
  Induction Motors, General Electric, Operating Under Trying Conditions................................... 19

National Electric Light Association, Atlantic City Convention of.. 34

Recent Important Sales..................................... 26
  (See also "Regulators, Induction.")

Rectifier, Mercury Arc (See "Illumination").
Regulators, Induction, Sales of........................... 31
Switchboard Devices, Automatic........................... 34
San Francisco Disaster (See "Motor Agency").

Traction:
  St. Francois County Electric Railway, The........... 34
  Trains, New Electric, on the Metropolitan Railway.... 34
  Washington Water Power Company's System and New Equipments.................................... 34
  West Shore Railroad, Electrification of the, between Utica and Syracuse.................................. 34

Transmission:
  Trenton Falls, N. Y., The Hydro-Elecric Development at.. 33
  (See also "Generating Systems.")

Turbines and Turbine Installations:
  Japanese Steam Turbine Electric Station.............. 33
  Present Status of the Steam Turbine.................. 34
  Steam Turbine, The, by Charles P. Steinmetz........ 17

RECENT INSTALLATIONS, CONTRACTS AND SALES

		Page
Altoona & Logan Valley Ry. Co.	Altoona, Pa.	28
American Bridge Co.	New York, N. Y	26
American Smelting & Refining Co.	New York, N. Y.	26
Anaconda Copper Mining Co.	Anaconda, N. Y.	27
Anderson Traction Co.	Anderson, S. C.	30
Atelier Thomson-Houston	Paris, France	31
Atlantic City Construction Co.	Atlantic City, N. J.	28
Atlantic Shore Line Ry. Co.	Portsmouth, N. H.	27
Australian General Electric Co.	Melbourne, Aus.	30
Bagnall & Hilles	Yokohama, Japan	31
Baltimore & Ohio R. R. Co.	Baltimore, Md.	28
Boston & Northern Street Ry. Co.	Boston, Mass.	27
British Thomson-Houston Co., Ltd.	Rugby, England	33
Buffalo General Electric Co.	Buffalo, N. Y.	26
Canada Car Co., Ltd	Montreal, Que.	34
Canadian General Electric Co.	Toronto, Ont.	31
Canon City, Florence & Royal Gorge Interurban Ry. Co.	Canon City, Colo.	30
Canton Light, Heat & Power Co.	Canton, O.	30
Central Illinois Construction Co.	Peoria, Ills.	27
Charlotte Consolidated Construction Co.	Charlotte, N. C.	28
Chicago, Burlington & Quincy Ry.	Chicago, Ills.	27
Chicago Edison Co.	Chicago, Ills.	30, 31
Chicago & Joliet Street Ry. Co.	Chicago, Ills.	28
Chicago & Milwaukee Ry. Co.	Highwood, Ills.	27
Cincinnati Gas & Electric Co.	Cincinnati, O.	30
Clemson Agricultural College	Clemson College, S. C.	29
Cleveland Crane & Car Co.	Cleveland, O.	30
Cleveland Electric Illuminating Co.	Cleveland, O.	30, 31
Cleveland Worsted Mills Co.	Cleveland, O.	30
Cluett, Peabody Co.	Troy, N. Y.	26
Colorado Springs Electric Co.	Colorado Springs, Colo.	30
Columbus Ry. & Light Co.	Columbus, O.	30, 31
Commonwealth Electric Co.	Chicago, Ills.	19
Commonwealth Power Co.	Jackson, Mich.	31
Conneticut Ry. & Lighting Co.	Greenwich, Conn.	27
Consolidated Gas, Electric Light & Power Co.	Baltimore, Md.	28, 31
Consolidated Ry. Co.	New Haven, Conn.	26
Day, J. H.	Cincinnati, O.	30
Dept. of the Interior, United States Geological Survey	Lujane, Colo.	30
Derby Gas Co.	Derby, Conn.	26
Detroit Edison Co.	Detroit, Mich.	31
Easton & Washington Traction Co.	Easton, Pa.	28
East St. Louis & Suburban Ry. Co.	East St. Louis, Ills.	28
Edison Electric Ill'g Co.	Boston, Mass.	31, 33
Edison Electric Ill'g Co.	Cumberland, Md.	29
Edwards, O. M.	Syracuse, N. Y.	26
Electric Construction Co. of Virginia	Richmond & Martinsville, Va.	29
El Paso Electric Ry. Co.	El Paso, Tex.	27

		Page
Engineers' Club	New York, N. Y.	33
Enterprise Mfg. Co.	Philadelphia, Pa.	30
Fairmont & Clarksburg Traction Co.	Fairmont, W. Va.	29
Fall River Electric Light Co.	Fall River, Mass.	27
Fonda, Johnstown & Gloversville R. R. Co.	Gloversville, N. Y.	26
French Thomson-Houston Co.	Paris, France	31
Frick Coke Co., H. C.	Fairchance, York Run & Wynn, Pa.	29
Fourneyron water turbine	Installed at Trenton Falls, N. Y. (Utica Gas & Electric Co.)	33
General Electric Co.	San Francisco, Cal.	26, 32
General Electric Co.	Schenectady, N. Y.	33, 34
Georgia Ry. & Electric Co.	Atlanta, Ga.	30
Grace & Co., W. R.	New York, N. Y.	31
Great Northern Power Co.	West Superior, Wis.	28
Henion & Hubbell	Chicago, Ills.	30
Heyl & Patterson, Incorporated	Pittsburg, Pa.	29
Hiroshima Power Co.	Hiroshima, Japan	31
Houston Electric Co.	Houston, Tex.	27
Hudson River Electric Co.	Albany, N. Y.	31
Hudson River Electric Power Co.	Utica, N. Y.	34
Hutchinson Interurban Ry. Co.	Hutchinson, Kas.	28
Interborough Rapid Transit Co.	New York, N. Y.	26
Kansas City Western Ry. Co.	Kansas City, Mo.	28
Kansas City & Westport Belt Ry. Co.	Kansas City, Mo.	28
Keihin Traction Co.	Keihin, Japan	31
Kennebec Light & Heat Co.	Augusta, Me.	27
Keuffel & Esser Co.	Hoboken, N. J.	27
Kiriu Water Power Co.	Kiriu, Japan	31
Kolar Gold Fields	Kolar, India	31
Lansden Co.	Newark, N. J.	30
Lerdo Torreon, Ferrocarril Electrico de	Gomez Palacio, Durango, Mexico	31
Lima-Callao Ry.	Lima, Peru	31
Lincoln Traction Co.	Lincoln, Nebr.	28
Madison & Interurban Ry. Co.	Madison, Wis.	28
Metropolitan Railways	London, England	34
Mexican General Electric Co.	Mexico City, Mexico	31
Mill Creek Power Co.	Salt Lake City, U.	30
Milwaukee Electric Ry. & Light Co.	Milwaukee, Wis.	28
Mitsui & Co.	Tokio, Japan	31
Morgan Engineering Co.	Alliance, O.	30
Nashville Ry. & Light Co.	Nashville, Tenn.	27, 31
National Ry. Construction Co.	Boston, Mass.	27
National Ry. Construction Co.	West Superior, Wis.	28
New Jersey & Hudson River Ry. & Ferry Co.	Hackensack, N. J.	27
New Orleans Ry. & Light Co.	New Orleans, La.	27
Norfolk & Portsmouth Traction Co.	Norfolk, Va.	29
Norfolk & Southern Rapid Transit Co.	Norfolk, Va.	29
North American Cold Storage Co.	Chicago, Ills.	33
Northern Electrical Mfg. Co.	Madison, Wis.	33
Northwestern Elevated Ry. Co.	Chicago, Ills.	28
Nunn, L. L.	Provo, U.	30
Oakland Gas & Light Co.	Oakland, Cal.	31
Omaha & Council Bluffs Street Ry. Co.	Omaha, Nebr.	28
Omaha Electric Light & Power Co.	Omaha, Nebr.	31
Osaka Electric Light Co.	Osaka, Japan	33
Pacific Light & Power Co.	Los Angeles, Cal.	33
Pelton water wheels	Installed at Manitou, Colo. (Pike's Peak Hydro-Electric Co.)	
Philadelphia Electric Co.	Philadelphia, Pa.	31
Philadelphia Rapid Transit Co.	Philadelphia, Pa.	29
Pike's Peak Hydro-Electric Co.	Manitou, Colo.	34
Pittsburg Reduction Co.	Pittsburg, Pa. & Shawinigan Falls, Que.	31
Potomac Electric Co.	Washington, D. C.	31
Public Service Corporation of New Jersey	Camden, N. J.	31
Public Service Corporation of New Jersey	Newark, N. J.	27
Pueblo & Suburban Traction & Lighting Co.	Pueblo, Colo.	30
Ransome Concrete Machinery Co.	New York, N. Y.	30
Raton Electric Light & Power	Raton, N. M.	30
Richmond & Chesapeake Bay Ry. Co.	Richmond, Va.	29
Rochester Ry. & Lighting Co.	Rochester, N. Y.	27
Rockford Edison Co.	Rockford, Ills.	28
St. Francois County Electric Ry.	Farrington, Mo.	34
San Francisco Gas & Electric Co.	San Francisco, Cal.	32
San Francisco Gas & Light Co.	San Francisco, Cal.	31
Santiago Lighting Co.	Santiago, Cuba	31
Santiago & San Bernards Ry.	Santiago, Chili	31
Scotts' Shipbuilding & Engineering Co., Ltd.	Greenock, Scotland	33
Scranton Ry. Co.	Scranton, Pa.	29
Shawnee Light & Power Co.	Shawnee, Okla.	28
Sherzer Rolling Lift Bridge	Boston, Mass.	26
Southern Michigan Ry. Co.	Kalamazoo, Mich.	28
Southwest Missouri Electric Ry. Co.	Webb City, Mo.	28
Stamford Gas & Electric Co.	Stamford, Conn.	31
Standard Sausage Co.	Chicago, Ills.	19
Stone & Webster	Boston, Mass.	27
Superior Water & Light Co.	West Superior, Wis.	28
Sussdorf Zaldo & Co.	Havana, Cuba	31
Syracuse Light Co.	Syracuse, N. Y.	31
Taber Mills	New Bedford, Mass.	27
Terre Haute Traction & Light Co.	Terre Haute, Ind.	28
Tholen Brothers	Leavenworth, Kas.	30
Topeka Ry. Co.	Topeka, Kas.	28
Twin City Rapid Transit Co.	Minneapolis, Minn.	28
Union Electric Light Co.	St. Louis, Mo.	31
United Gas Improvement Co.	Philadelphia, Pa.	27
United Railways Co. of St. Louis	St. Louis, Mo.	28
United Shoe Machinery Co.	Beverly, Mass.	27
Utah Copper Co.	Garfield, U.	26
Utah Light & Ry. Co.	Salt Lake City, U.	30, 31
Utica Gas & Electric Co.	Trenton Falls, N. Y.	33
Virginia Passenger & Power Co.	Richmond, Va.	29
Washington Water Power Co.	Spokane, Wash.	34
Waterloo, Cedar Falls & Northern Ry. Co.	Waterloo, Ia.	28
Weidenthal-Gosliner Electric Works	San Francisco, Cal.	32
Wellington Tramways	Wellington, New Zealand	30
West Shore R. R. Co.	Utica—Syracuse, N. Y.	34
Wheeler-Green Electric Co.	Rochester, N. Y.	30
Wilmington City Ry. Co.	Wilmington, Del.	29
Wirt Mfg. Co., H. C.	Hanson, Mass.	31
Witherbee, Sherman & Co.	Mineville, N. Y.	34

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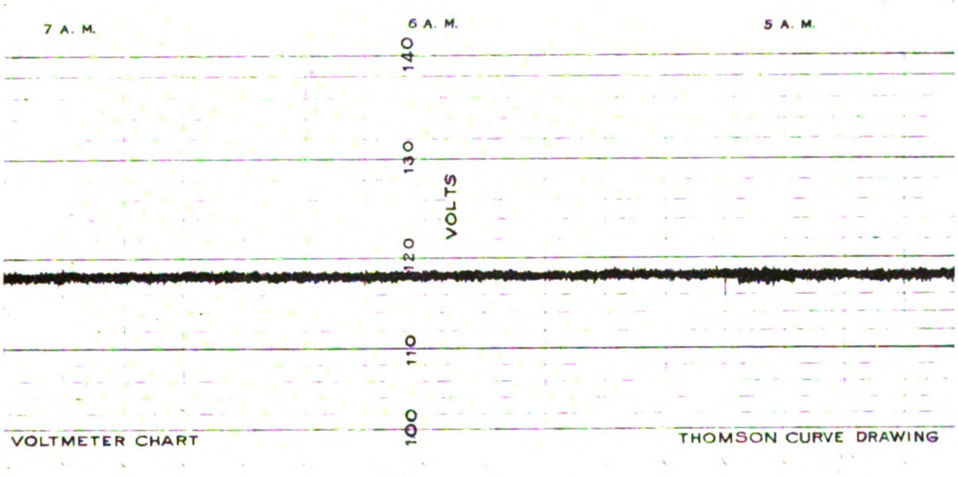
GENERAL ELECTRIC COMPANY
REVIEW

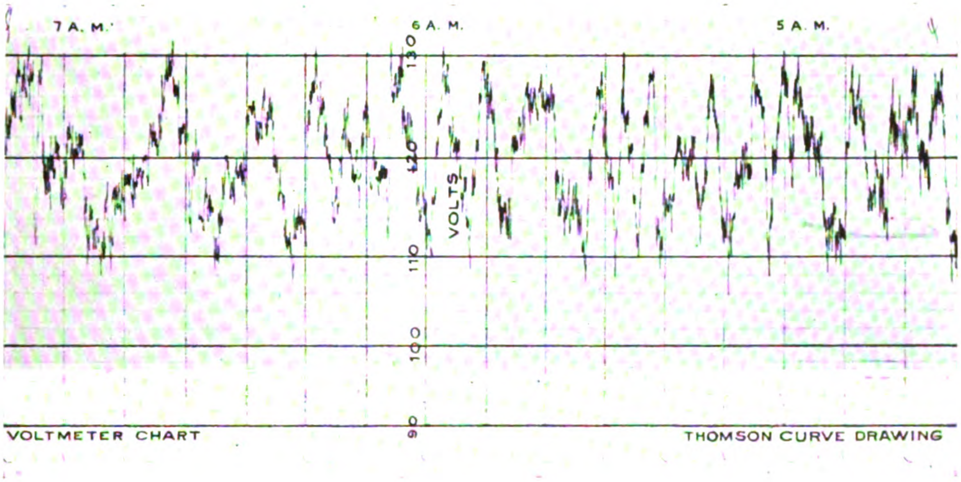
Vol. VII SCHENECTADY, N. Y., AUGUST, 1906 No. 4

PERFORMANCE OF TYPE BR FEEDER REGULATOR, RECORDED BY THOMSON CURVE DRAWING VOLTMETERS

By George Rockwell, Jr., Commercial Dept.



Feeder Side of Regulator



Generator Side of Regulator

FIG. 1
Thomson Curve Drawing Voltmeter Charts Showing Voltage Regulation by Type BR Regulator

The type BR Feeder Regulator, designed for automatically effecting close voltage regulation on A. C. lighting feeders, is the result of several years' development, and has been thoroughly tried out in actual service. It is fully described in a forthcoming Bulletin.

The charts reproduced in the accompanying illustration, Fig. 1, were taken simultaneously by two Thomson Curve Drawing Voltmeters, one on either side of a type BR regulator, designed for a 10 per cent boost or lower and connected in a circuit representing severer conditions than would be likely to occur in any actual service. In both charts the clearly defined and accurate record given by the Thomson curve drawing instruments is well exemplified. The instruments used in taking these records were equipped with 20 to 1 ratio potential transformers.

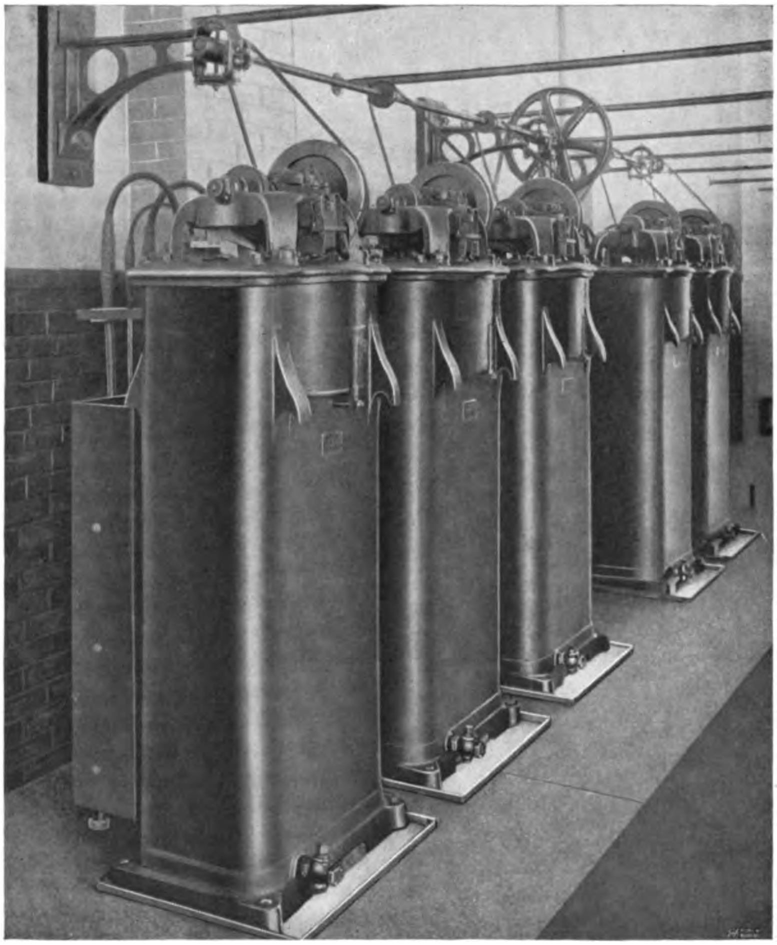


FIG. 2
Typical Installation of Five Type BR Feeder Regulators at the Dock Street Sub-station, Schenectady, N. Y., on Lighting Circuits of the Schenectady Illuminating Co.
The line shaft to which the regulators are belted is driven by a small D. C. motor.

It will be noted that the actual maximum voltage variation on the generator side, during the 2 hours and 40 minutes' run shown, is 508 volts, or approximately 22.1 per cent of the normal generator voltage; whereas on the feeder side the maximum voltage variation is held down by the regulator to approximately 40 volts actual, or 1.7 per cent, except at the one point where the voltage variation was allowed to exceed the capacity for which the regulator was designed, as shown by inspection of the two charts. The point of minimum voltage (106), recorded at 5-09¾ on the chart of generator voltage, is about 1.3 volts beyond the boosting capacity of the regulator, as indicated by the drop at the corresponding point on the chart of feeder voltage. The apparent discrepancy in time is accounted for by the fact that the chart of the feeder side was started slightly ahead of the chart of the generator side.

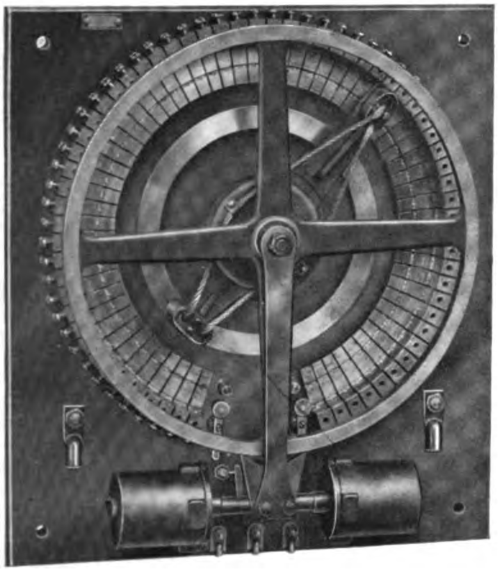


FIG. 1
100 Amp. Solenoid Operated Remote Control Rheostat Switch

Fig. 2 shows a group of these regulators that was installed in the Dock Street Sub-station several years ago, connected in feeders of the Schenectady Illuminating Co.

SOLENOID OPERATED REMOTE CONTROL RHEOSTAT SWITCH

By W. C. Yates, Engineering Dept.

The accompanying illustrations, Figs. 1 and 2, show a new type of Remote Control Field Rheostat Switch which has been developed to take the place of the bulky and expensive motor driven switch.

This rheostat switch is designed to carry a current of 100 amp. and is operated by a current of about 3/4 amp. at 125 volts. The switch arm is carried around by means of dogs which engage the knurled rim of the wheel, and to which a reciprocating motion is imparted by a core, or plunger, actuated by the solenoids A, A (see Fig. 2). The single-pole, double-throw control switch B is used to throw the operating circuit to one solenoid or the other, depending upon the direction in which it is desired to operate the rheostat switch. The reciprocating motion is accomplished by means of a pair of make and break points, C, C, one for each direction of motion. When the rheostat switch arm reaches either end of its travel it opens the operating circuit at one of the limit switches D, D, the operation of which will be clear from inspection of Fig. 1.

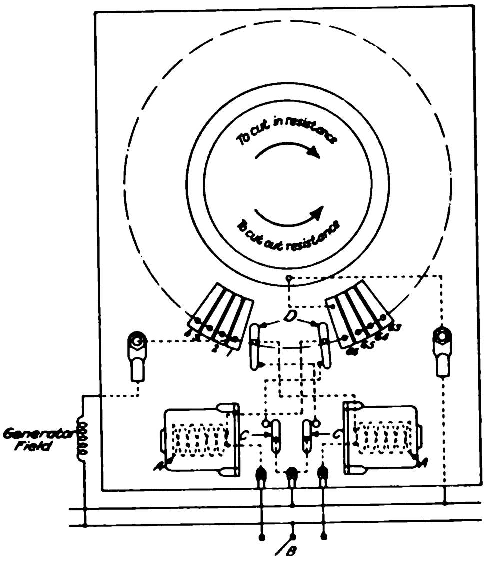


FIG. 2
Connections of Solenoid Operated Remote Control Rheostat Switch

A, A, Solenoids
C, C, Make and Break Switches
B, Control Switch
D, Limit Switches

Besides being smaller and simpler than the old type of motor driven switch, this device has the advantage of having no momentum to carry it beyond the desired point of rest.

Orders have been received for sixty of these 100 amp. remote control switches, including an order of forty-five for the Chicago Edison Co., which has also ordered six 200 amp. switches of the same type.

RECENT IMPORTANT SALES

New York Office

Ansonia Mfg. Co., Ansonia, Conn.

One ATB 36-125-200-240 volt generator, with exciter.

Eight 220 volt form K induction motors, aggregating 85 h.p.

Three switchboard panels.

Birmingham Ry., Light & Power Co.,
Birmingham, Ala.

One ATB 12-3000-600-2300 volt Curtis steam turbine-generator.

An unusual feature of this turbine-generator is that it is to be operated non-condensing. It is the second unit of the same type and capacity to be installed. The unit already installed is operating continuously in regular service and shows up much better than the reciprocating engine units previously installed. An addition to the power house, just being completed, is arranged for four of these units.

Copper Queen Consolidated Mining Co.,
New York, N. Y.

For Dawson, N. M.

Switchboards for main station and for No. 1 Mine, Tipple, Washery, and No. 5 Mine Substations.

De Laval Steam Turbine Co., Trenton, N. J.

For Garden City, Kas.

Two ATB 8-112.5-900-6600 volt generators, to be direct coupled to this company's turbines for installation on a Government irrigation plant.

Two MP 6-11-900-125 volt compound wound exciters.

General Vehicle Co., Long Island City, N. Y.

Sixty-four GE-1010 85 volt 22 amp. 1250 rev. per min. automobile motors, with gears, pinions, back geared shaft, and gear casing.

Hudson River Electric Power Co.,
Glens Falls, N. Y.

Sixteen 220 volt form L induction motors, aggregating 52 h.p.

Ingersoll Rand Co., Phillipsburg, N. J.

Twenty CQ-2-220 volt (3 h.p. 1600) shunt wound motors.

Ten I 4/8-3-1800/900-K-440 volt two speed induction motors.

Thirty I 4/8-3-1800/900-K-220 volt two speed induction motors.

These motors are for equipping Ingersoll Temple drills. About two hundred motors have been bought during the past five months by this company for equipping these tools.

Long Island Electric Ry. Co.,
Long Island City, N. Y.

Two HC 6-500-500-600 volt rotary converters.

Two ABH 25-550-13200-430 volt transformers.

One blower set consisting of a 55 in. 8000 cu. ft. per min. blower driven by a 3 h.p. 750 rev. per min. induction motor.

Memphis Street Ry. Co., Memphis, Tenn.

Twenty four-motor GE-80 car equipments, with K-28 controllers.

Last year this plant was taken over by Ford, Bacon & Davis and orders were then placed for two-motor and four-motor equipments. The present order is simply carrying out the policy of this company to give Memphis an up-to-date street railway equipment.

New York City Ry. Co., New York, N. Y.

Forty-three sets K-27 controllers with handles.

Eighty-six Cat. No. 14390 MQ 200-400 amp. circuit breakers.

Eighty-six Cat. No. 36881 MS-8 main motor switches.

Forty-three sets CG rheostats for use with two-motor GE-57 equipments.

Forty-three sets made-up controller cables.

New York Edison Co., New York, N. Y.

For Waterside Station No. 2.

Two three-phase generator panels.

Two four-circuit three-phase feeder panels.

Additional switchboard equipment.

Boston Office

Everett Mills, Lawrence, Mass.

One ATB 4-500-1800-T-600 volt Curtis steam turbine-generator.

One C 2-25-3600-125 volt, non-condensing Curtis steam turbine-exciter.

One I 6 1/2-1200-550 volt motor driving a 2 in. by 3 in. vertical pump for maintaining step pressure.

One motor generator exciter set consisting of a CE 4-10-1200-125 volt generator direct connected to an I 6-15-1200-550 volt induction motor.

Holyoke Machine Co., Holyoke, Mass.

One ATB 8-100-900-600 volt generator with direct connected exciter.

One four-panel switchboard.

Joslyn Mfg. Co., South Scituate & Hope, R. I.

The following 2300 volt units, to serve as generators or motors:

One ATB 10-200-720.
One ATB 8-100-900.
One ATB 8-75-900.

Also:

One 3-panel switchboard.

Three 3.5 kw. 125 volt CQ exciters.

One I 12-175-600-L-2080 volt induction motor.

One I 10-60-720-L-2080 volt induction motor.

The above installation is worthy of special consideration, first because of the efficient method of operation, and secondly because the mills operated by this company are among the first to adopt the use of high voltage motors inside the buildings to operate the machinery.

This company operates three mills for the manufacture of shoe laces and corset strings: The

Richmond Mill, on the Ponogansett River, the Ponogansett Mill, situated on the same stream two miles above, and the Rockland Mill, situated on the west about three-quarters of a mile from the Ponogansett Mill.

These three mills, like many others, depend upon two sources of power to drive them, namely, water power ordinarily, and steam power when the water power fails during the dry season.

The following interesting power transmission scheme is used. The Rockland Mill, which is situated between the other two mills, contains a small power house in which is installed a water wheel driven, 200 kw., 2300 volt three-phase generator, with switchboard. A 175 h.p. induction motor, supplied from this generator, drives the mill. A steam engine is held in reserve to the water power for driving the generator, but will probably never be used, as at dry periods all of the available water is utilized by this mill alone, the pond near the Ponogansett Mill serving as a storage reservoir against the dry periods. The Rockland Mill power station thus supplies power to operate the Rockland Mill, and to assist in operating the other two mills all the year round.

The Richmond Mill runs twenty-four hours per day ordinarily, using water power, but has an auxiliary steam engine, also a 75 kw. synchronous motor (or generator). When the plant is operating by water wheel, this unit is belted to the line shaft and runs in multiple with the 200 kw. generator installed at the Rockland Mill, helping to take its share of the load. When water is low, this unit is used as a motor supplied from the Rockland Mill generator, the Richmond Mill steam engine being very seldom if ever used. The idea is to get along without the use of the engines. This building is lighted by a 20 kw. transformer supplied by the transmission line which connects the three mills.

The Ponogansett Mill operates ten hours per day, and depends entirely on water power when available. In this mill is a 60 h.p. induction motor, also a 100 kw. synchronous unit which is used as a generator, or as a synchronous motor to drive this mill when water is low, operating in multiple with the units at the other mills, and thereby helping out in saving coal, or water, as the case may be, for the other mills. This building, also, is lighted by current from the transmission line.

The transmission line enters each mill in rubber insulated lead covered cables, laid in a loricated galvanized iron conduit with sheath grounded. The motor frames are also grounded, so that all danger of fire or shock is eliminated.

STONE & WEBSTER, BOSTON, MASS.

For Minneapolis General Electric Co., Minneapolis, Minn.

Switchboard for this generating station, consisting of:

Three 13200 volt, 4000 kw., three-phase outgoing line panels.

Two 2300 volt, 1000 kw., three-phase outgoing line panels.

Equipment for three present incoming line panels.

Switchboard for Fifth Street Sub-station, consisting of:

Two 13200 volt, 4000 kw., three-phase incoming line panels.

Two 1000 kw. combination A.C. and D.C. three-wire rotary converter panels.

Ten three-wire feeder panels.

One blank feeder panel.

One pressure panel.

Additional apparatus including lightning arresters, etc.

Special features of this sub-station switchboard are the extraordinary compactness with which the whole switchboard is arranged and the fact that the D.C. rotary converter switches are electrically operated.

Philadelphia Office

AJAX METAL CO., PHILADELPHIA, PA.

Eleven two-phase, 60 cycle, 220 volt motors, aggregating 181 h.p.

BETHLEHEM STEEL CO., SOUTH BETHLEHEM, PA.

One MP 12-500-90-250 volt generator.

CLARA MFG. CO., GASTONIA, N. C.

For transformer house:

Three 100 kw. 11000/575 volt transformers.

One 15 kw. 575/115 volt transformer.

Lightning arresters.

For equipment of mill:

Twelve I 6-20-1200-K-550 volt inverted motors.

One I 8-50-900-L-550 volt inverted motor.

Induction motor panel.

Oil switches and wiring material.

EDISON ELECTRIC ILL'G CO., WILLIAMSPORT, PA.

One three-unit motor generator set, consisting of an ABQ 10-325-450-2300 volt unit, direct connected to two CL 6-150-450-125 volt units which can be operated as generators or motors.

One A.C. generator panel.

One D.C. generator panel.

CORPS OF ENGINEERS, U. S. ARMY,
WASHINGTON, D. C.

For State, War and Navy Building, Washington.

One C 4-75-2400-250 volt 150 lb. non-condensing Curtis steam turbine-generator.

One balancer set.

Switchboard, cables, etc.

MONARCH COTTON MILLS CO., DALLAS, N. C.

Three 550 volt type L induction motors, aggregating 195 h.p.

One HT 60-15-550-115 volt transformer.

Three oil switches.

Eighteen Cat. No. 9182 arc lamps, with concentric diffusers.

Three switchboard panels.

Lightning arresters.

Cabinet panels.

Wire and wiring material.

PITTSBURG, HARMONY, BUTLER & NEW CASTLE
STREET RY. CO., PITTSBURG, PA.

Twelve four-motor GE-100 1200 volt equipments, with Sprague-General Electric type M control.

Twelve emergency straight air brake equipments, adapted for multiple unit operation.

Two ATB 8-1500-900-13200 volt Curtis steam turbine-generators.

Two Curtis steam turbine-exciters.

Two 200 kw. motor generator sets.
Switchboard.
Two sub-stations, each containing:
Two MP 4–200–720–600/650 volt generators direct connected to ATB 10–425–720–13000 volt synchronous motor.
Transformers.
Switchboard panels.
Twenty-eight thousand standard terminal rail bonds.

Pressed Steel Car Co., McKees Rocks, Pa.

Fifteen 550 volt, 50 cycle, three-phase induction motors, aggregating 167.5 h.p.

Spencer Mountain Mills, Lowell, N. C.

Three H 60–150–11000–575 volt transformers.
One H 60–30–11000–575 volt transformer.
Four 550 volt type L induction motors, aggregating 180 h.p.
Twelve I 6–20–1200 K 550 volt induction motors.
One line panel.
TA regular, oil switches, wiring material, etc.

Atlanta Office

Savannah River Power Co., Anderson, S. C.

Six 150 kw. type H transformers.
Two 500 kw. type WC transformers.
Two 375 kw. type WC transformers with lightning arrester equipments, regulators and switches.

Tampa & Sulphur Springs Traction Co.,
Tampa, Fla.

Two MP 8–300–100–S–525/575 volt railway generators.
Eight two-motor GE-90 (50 h.p.) equipments, with K-10 controllers.
Four switchboard panels.

Virginia-Carolina Chemical Co.,
Charleston, N. C.

One 200 h.p. form K induction motor.
One 110 h.p. form M induction motor.
One 75 h.p. form M induction motor, with switchboard.

Denver Office

American Smelters Securities Co.,
New York, N. Y.

For Utah Copper Co., Garfield, U.
One LM-103 1-4 1/2 ton locomotive.
One MP 6–100–250–125/250 volt three-wire generator.

Boston Consolidated Mining Co.,
Salt Lake City, U.

Three H 60–75–5000–220/440 volt transformers.

Morse Bros. Machinery & Supply Co.,
Denver, Colo.

For Manhattan Mining & Power Co., Twin Lakes, Colo.
One ATB 6–50–1200–P–2300 volt generator, with switchboard panel.

In addition to above apparatus there have been sold thirty-nine D.C. motors, aggregating about 192 h.p., and twenty-nine A.C. motors, aggregating about 832.5 h.p.

San Francisco Office

Copper Queen Consolidated Mining Co.,
New York, N. Y.

Five 200 kw. rotary converters.
Fifty-five type H transformers, aggregating 2075 kw. capacity.
Sixteen 100 amp. oil switches.

H. S. Crocker Co., San Francisco, Cal.

Twenty-three D.C. constant and variable speed motors, for the equipment of a press room in a publishing house.

Edison Electric Co., Los Angeles, Cal.

Seven WC transformers, aggregating 1750 kw. capacity.
Three IRT regulators, aggregating 164 kw capacity.

Northern Electric Co., Chico, Cal.

Thirteen switchboard panels.

St. Louis Car Co., St. Louis, Mo.

Fifty four-motor GE-73 equipments with type M control.

United Railways of San Francisco,
San Francisco, Cal.

Twelve switchboard panels.

J. W. Watkins & Co., San Francisco, Cal.

Twenty-two motors, aggregating 120 h.p. capacity.

Washington Water Power Co.,
Spokane, Wash.

Ten two-motor GE-87 equipments with K-11 controllers.

Weidenthal-Gosliner Electric Works,
San Francisco, Cal.

Sixty-eight D. C. motors, aggregating 205 h.p. capacity.
Eighty-one induction motors, aggregating 291 h.p. capacity.

Yamhill Electric Co., Newburg, Ore.

One ATB 12–200–600–2300 volt generator with exciter and panel.

Small Motor Department

Enterprise Mfg. Co., Philadelphia, Pa.

Thirty CQ motors, aggregating 29 h.p.
Forty-eight 1/4 h.p. single-phase motors.

W. H. Kistler Stationery Co., Denver, Colo.

Twenty-eight CQ motors, aggregating 36 h.p.

Reading Iron Co., Reading, Pa.

Six CE back geared motors, aggregating 40 h.p.
Seven CR motors, aggregating 35 h.p.

Tholen Bros., Leavenworth, Kas.

For State Penitentiary, Leavenworth, Kas.
Fourteen CQ motors, aggregating 56 h.p.

Western Union Telegraph Co., New York, N. Y.

Sixteen motor generator sets.

SEWERAGE PLANT FOR THE CITY OF SALEM, MASS.

In 1900 a Commission was appointed by the City Council of Salem, Mass., to report upon means for disposing of the sewage, which was a troublesome nuisance and had a detrimental effect on the health of the people. Up to that time there had been no well organized plan to this end. The neighboring town of Peabody allowed its sewage to be carried away by the North River, running through the heart of Salem, while Salem itself discharged its sewage into this same river and into the inner bay at the mouth of the river.

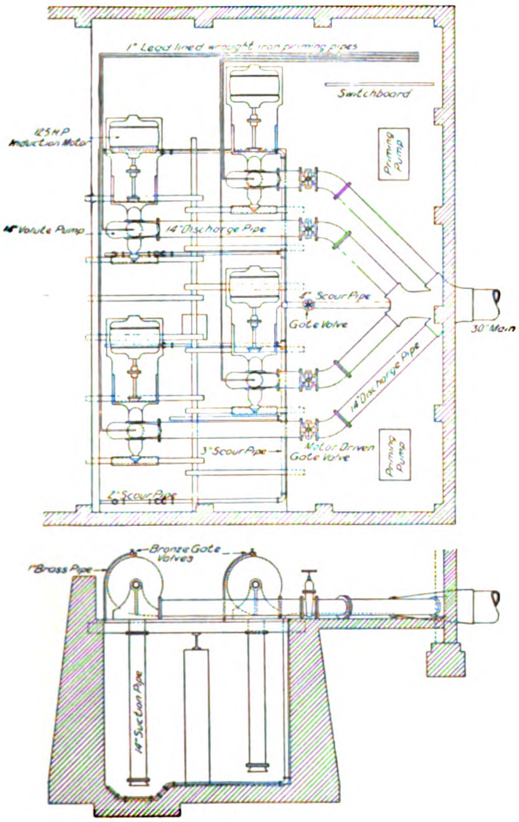


FIG. 1
Plan and Vertical Section of the Electric Pumping Station of the Salem, Mass., Sewerage Plant

After consultation with engineers the following plan was reported.

It was provided to converge the many branch sewers into one main 72 in. trunk line and carry this trunk line through the city to an outfall at sea, as remote from the city as possible. As Salem is practically at sea level, it was necessary to provide other means than gravity to create a flow from the city to the outfall, and the plan called for a pumping station at the junction of the main trunk line and the outfall sewer. In order to shorten the length of pipe to be laid under the bay, from the shore to the outfall point at Great Haste Island, it was provided to locate the pumping station at the edge of the shore, at a point on Salem Neck.

The 72 in. trunk sewer terminates at the pumping station in a shallow well, dropping but one foot below mean low tide water. As this well will have no capacity for storage purposes, it will be necessary to dispose of the sewage practically as fast as it accumulates. The outfall main, which is to be a 30 in. cast iron pipe 9700 ft. long, dips under the ship channel that runs between Salem Neck and Great Haste Island, and has a "V" or pocket at this point, which tends to accumulate solids. In order to scour the pipes, the pumps must be able to force the discharge through them at the rate of 6 ft. per second, or 19 million gal. per twenty-four hours. This duty, however, is demanded for only two hours out of every twenty-four, while the ordinary flow at present is estimated at not more than 6 million gal. per twenty-four hours; so that for the major part of the time the pumps will be considerably underworked. The varying height of the tide also is to be taken into consideration, as between mean low and mean high water there is 11 ft. difference. The engineering problem resolved itself into the taking care of 6 million gal. of sewage during twenty-two hours, and of 19 million gal. during the remaining two hours of every twenty-four, against minimum heads varying from 7 to 8 ft., according to the height of the tide, and against maximum heads, corresponding to the larger and more rapid discharges, varying from 49 to 60 ft.

Three motive powers for driving the pumps were considered by the Commission—the steam engine, the gas engine and the electric motor—although previous to June, 1904, all of the estimates on the pumping station had been made on the basis of using steam driven pumps. Realizing the permanence of the installation, careful attention was given to all of the merits of each of these motive powers, on the basis of operation and maintenance rather than first cost, with the result that the electric equipment shown in the accompanying illustrations was finally selected.

In working up the electric drive proposition, as there were no electrically driven pumping stations in the vicinity of Salem from which to draw conclusions, it was first of all necessary to interest the Commission in the possibilities of the electric motor for this work. The next step was to submit a plan of a proposed electrically driven station, with estimates of total cost and maintenance. The Commission thereupon obtained proposals from representative builders of steam and gas engine driven pumps, the engineering requirements being the same in each case, viz: to provide a unit or units having guaranteed duties of six million gal. per twenty-four hours against a head of 18 ft., of twelve million gal. against a head of 35 ft. and of nineteen million gal. against a head of 60 ft.

The gas engine builders proposed a separate unit for each head, on account of the limited speed range of this engine; but the first cost was so high that they submitted a plan following the suggestion of the induction motor drive, viz. the installation of four three-speed units, each of six and one third million gal. capacity. The plan provided for the combining of these units to give three duties: a duty of six and one third million gal. per twenty-four hours obtained by one unit running at 300 rev. per min. and pumping against a head of 18 ft. a duty of twelve and two thirds million gal. obtained by two units running at 450 rev. per min. against a head of 35 ft., and a duty of 19 million gal. obtained by three units running at 600 rev. per min. against a head of 60 ft.—the fourth unit being a reserve.

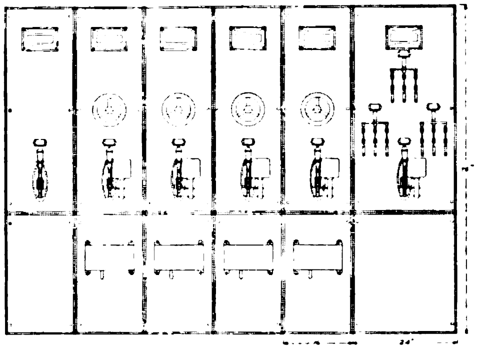


FIG. 2

Switchboard at Salem, Mass., Sewerage Plant, Consisting of Six Black Enamelled Slate Panels, Equipped as Follows:

One 500 h.p., 2080 volt incoming line panel (at the left), equipped with indicating wattmeter and K-3 hand operated non-automatic oil switch, and with recording wattmeter on the back of the panel.

Four main pump motor panels, each equipped with indicating wattmeter, T-23 oil type controller, K-3 hand operated electrically tripped oil switch, and Chapman automatic switch for operating the main valve motor.

One priming pump motor and lighting circuit panel, equipped with ammeter, one lighting circuit switch and two priming pump motor switches, and one K-3 hand operated electrically tripped oil switch on the primary side of a bank of three 2 kw. transformers for supplying the priming pumps and the lighting circuit.

The steam pump manufacturers proposed to obtain the required duty by installing two cross compound units, each of 9 million gal. capacity; obtaining the speed required for the lowest duty by operating one unit with one cylinder cut out, and the higher duties by using both cylinders and adjusting the cutoff.

In comparing these three proposed methods of operating the pumping station, curves were prepared showing the horsepower necessary for each system; and estimates of the building required for each system, and of the operating expense of each, were also submitted. The first cost of the gas engine station was about twice that of the electric drive, while the steam station was about three times as expensive. The floor space required by the gas engine station was about three times as great, and by the steam station about five times as great, as the floor space required for electrical equipment. With coal at $4.00 per ton, gas at 75c per thousand, and electric power at 1 1/4c. per h.p.-hr. it was estimated, taking all station expenses into account, and putting them on a 16 hour basis, that it would cost $21,000 a year with steam, $15,000 with gas, and $14 000 with electricity. Other arguments which appealed strongly to the Commission in favor of the motor drive, and which would no doubt have justified the Commission in selecting the electric drive even at a higher cost of operation, were: simplicity of operation in starting and running, freedom from danger of complete shut-down for repairs, ease of handling the whole station from one point, the large number of combinations of units available (as all four induction motors were duplicates, any three could run at the time of maximum demand), noiselessness, cleanliness, and minimum attendance.

The central station company which is to supply power for operating this pumping station felt justified in making the low rate of 1 1/4c per h.p.-hr. on account of the desirability of the business: since it was stipulated that no power was to be taken at the time of the peak load on the station, and that the maximum demand for power (for flushing the sewer) was to be made only at the time of valley load.

The apparatus contracted for (see the accompanying illustrations, Figs. 1 and 2) consists of:

Four 14 in. volute horizontal centrifugal pumps, each direct connected to and mounted on the same base with a 12 pole, 125 h.p., 600/450/300 rev. per min., 2080 volt form K induction motor complete with controller for changing the pole combination and with compensator for starting the motor and bringing it up to the lowest speed at which the controller will act.

Two dry air vacuum pumps, each direct driven from the lighting transformers by a 5 1/2 h.p., slow speed, 110 volt form K induction motor.

Four 14 in. induction motor driven valves, one in each main pump discharge pipe.

The switchboard consists of six panels, comprising one incoming panel, four motor panels and one combination priming pump and lighting panel. The operating mechanism, with the exception of the motor starting compensators, which are located beside their respective machines, is all concentrated at the switchboard, so that except for starting the pump motors the entire pumping station may be operated from this point. A speed changing controller for a pump motor and a switch for controlling the corresponding main valve motor are located on each motor panel. Each main valve motor is controlled by a switch located on the same panel with the switch controlling the motor.

A very ingenious priming system, devised by Mr. Spencer, Chairman of the Sewerage Commission, has been adopted. All four priming pipes, from the main pumps, lead into a trunk pipe back of the switchboard, and the corresponding valves are all located on the sub-base of the priming pump and lighting panel. The trunk pipe leads into a drum, out of the top of which the air is exhausted by either one of the dry air pumps; the two air pump valve stems being brought to the switchboard, so that the valve of the idle pump may be closed. Water is prevented from being drawn over into the dry air pump, through any chance neglect, by a ball float arrangement connected to a two-part balanced valve. Any water that may be drawn into the drum can be blown off by closing both of the priming pump valves and opening a valve in a discharge pipe.

It may be interesting to note that the contract price for all of the apparatus was approximately the same as in the estimate submitted with the original electrical plans, notwithstanding many additions and changes.

ELECTRIC GLUE POTS

By F. M. Vogel & H. J. Mauger

The glue pot is one of the most successful and important applications of electric heating used in the mechanical arts, not only because of the large number of glue pots in use in the various trades, but also on account of the obvious improvement, in safety and convenience, effected by the use of electricity for heating compared with steam, gas, coal, or kerosene oil.

Until the General Electric Company glue pots were placed on the market, however, electric glue pots had one feature of design —the water jacket, or water bath—which had been inherited, so to speak, from the ordinary glue pot, and which was indirectly a source of so much trouble as to render these early types of electrically heated glue pots practically inoperative.

The water bath is a necessary feature of the ordinary glue pot, in which the source of heat is not subject to perfect control, inasmuch as this water bath serves not only to distribute the heat evenly to the glue but also to prevent the glue from becoming overheated. The most successful method of heating the ordinary glue pot, especially where steam is available, is by a large water bath heated by a steam coil, the water bath being sometimes arranged to hold several glue pots, as in pattern-makers' shops, bookbinderies, etc. This method, however, has the serious disadvantages that the necessary steam piping becomes leaky and collects dirt. Moreover, the glue pot cools off quickly when the workman removes it from the bath and takes it to his bench, or wherever his work may be around the shop; a disadvantage which is eliminated, of course, by the successful electrically heated glue pot, with its inherent portability and facility of connection to outlets conveniently located.

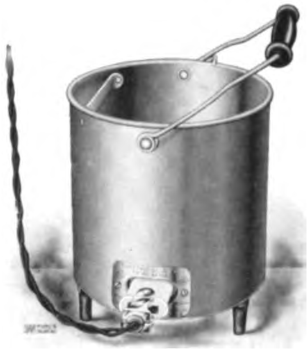


FIG. 1
Standard Single-Heat General Electric Glue Pot for General Use

The trouble with the early types of electrically heated glue pots, designed with the water bath, was that when the water bath ran dry—which it is frequently allowed to do, through carelessness—the heating unit would burn out and destroy the utensil. Efforts to overcome this difficulty by making both the glue pot and water bath of seamless sheet copper resulted only in extra cost of manufacture, without preventing the rapid deterioration, or outright destruction, of the utensil.

In the standard General Electric glue pot, shown in the accompanying illustrations, Figs. 1 and 2, the necessary evenness of heat and freedom of danger from overheating are obtained just as positively as in the best steam coil arrangement, but in an entirely different and far superior manner. The glue pot consists of a pure aluminum casting having a high conductivity for heat, and the watts input and the amount of radiating surface of the pot are so proportioned that while the glue is always kept hot the final temperature of the walls and bottom of the pot never exceeds 100 deg. C. Beside the obvious improvements of uniform operation and durability possessed by this design over all electric glue pots having water jackets there are the following additional advantages:

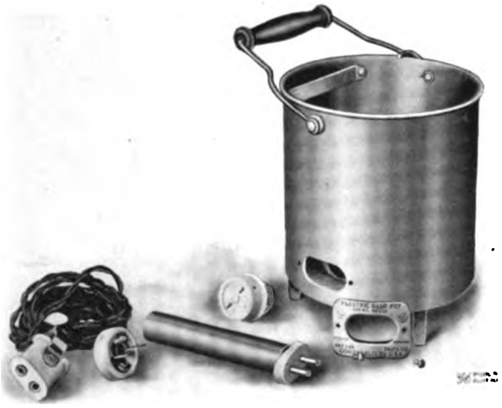


FIG. 2
Standard Single-Heat General Electric Glue Pot, with Heating Unit and Connections Removed

1. The heating element is of the well known cartridge type, possessing the characteristic features of simplicity, renewability and long life.

2. The glue never becomes overheated. It may therefore become entirely dried up without losing its ready solubility or its strength. This fact has been proved by actual tests, by breaking joints made of new and old glue in a testing machine.

3. The heat is applied directly, resulting in the following low energy consumptions:

Size	Watts Consumption, General Electric Type	Watts Consumption on Low Heat, Competitors' Water Jacket Type
1 qt.	85	170
2 qt.	115	220
4 qt.	185	275

4. Owing to the unctuous surface of the aluminum, the glue does not stick to it. This feature results in a clean pot and a noticeable saving of glue.

A General Electric Company glue pot will operate satisfactorily on a very wide range of voltage, and in the single heat type is as nearly "fool-proof" as it is possible to conceive. The time required to melt up the glue varies considerably, depending upon whether the device is used on high or low voltage, and on the amount of glue in the pot. If the pot is full of glue and the glue is stirred a few times it becomes ready for use in about thirty minutes.

To meet the demand for a glue pot that will heat up in twelve or fifteen minutes a two heat, 95/115 volt device has been developed, using the high heat for melting the glue and the low heat for maintaining the temperature after the glue is melted. The 2 qt. and 8 qt. sizes are now in production.

The advantages attained by designing the electric glue pot with an indestructible heating unit which will melt the glue quickly without danger of heating it unevenly, or of overheating it in case the water bath runs dry, are strikingly shown in the case of an installation of General Electric glue pots of special design in the publishing house of Ginn & Company, which is one of the best known schoolbook publishing houses in the country.

About two years ago Ginn & Company's engineer called the writers' attention to the great desirability of an electric glue pot. He said that the steam heated glue pots which were then in use by this concern were a continual source of annoyance, particularly from leaking steam pipes. Considerable damage had been done to the stock, from time to time, by the moisture from leaky pipes, and in one case the bursting of a pipe spoiled a large number of books. Steam had to be carried at 100 lb. pressure, and the entire layout was unsightly, dirty and out of keeping with the model bookmaking plant in which it was installed.

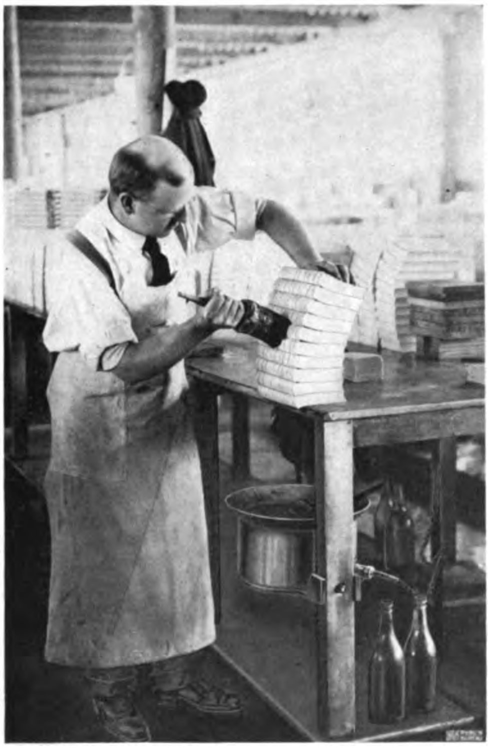


FIG. 3

Bookbinder Using the General Electric Glue Pot

Reproduced from a photograph taken at the bindery of Ginn & Company, Cambridge, Mass., where fifty of these devices are now installed.

In order to overcome these difficulties, several different makes of electric glue pot, in the market at that time, were tried for this work. All of these devices, however, proved unsatisfactory, as they were in constant need of repair.

The General Electric Company took up the problem of the design of a satisfactory glue pot for bookbinders' use. The standard General Electric glue pot without water jacket had meanwhile been developed at the Lynn Works, and had proved successful in practical use.

Bookbinders require a large, shallow glue pot of about two gallons capacity. The design that was finally developed, of which about fifty are now installed in Ginn & Company's bindery, replacing all of the old steam coil glue pots there, is shown in Fig. 3. This view, which is reproduced from a photograph, shows an obviously advantageous feature of the electric glue pot, i. e., the facility with which it may be placed just where it is needed: just underneath the individual bookbinder's table, in this instance. The books, minus their covers, are stacked in small piles, so that the glue may be applied to the backs of all of the books in the pile at one time. In this way from one to two thousand books can be glued in one day by each workman. After the books are glued they are taken to the cover machine, which automatically puts on the covers.

The plant of Ginn & Company is model and up-to-date in every way, and is equipped with its own electric power plant with individual motor drives aggregating about 400 h.p., and with the latest automatic machinery known to the book printing and binding trade.

In this connection, another interesting application of electric heating has recently been made at this plant: the heating of the heads of embossing presses electrically instead of by steam. Several 500 watt cartridge flat iron units were inserted in holes drilled in the heads of these machines and connected to the supply circuit through a suitable controlling switch. The operation of this arrangement has proved more satisfactory than the steam coils formerly used.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

An Investigation of the Steam Turbine

[Elec. Rev., July 14, 1906, p. 51]

An abstract of the report of the National Electric Light Association Committee, giving a brief account of visits to the works of the General Electric Company at Lynn and Schenectady. A number of novel features of construction were noted by the committee, including a valve mechanism, and a steel plate construction of wheels. The number of medium and small sizes of turbines now being built is increasing. The total number of Curtis steam turbine-generators was reported to be 592 units, aggregating 580,325 kw. Of these, 385 units are of 500 kw. capacity or larger.

Electrical Machinery in South America

[Elec. Rev., July 14, 1906, p. 76]

A brief account of the following three important installations: additional generating station equipment for the Empresa Electrica de Santa Rosa on the River Rimas, Peru, including two 1200 kw. generators; an additional 2000 kw. generator, and additional transformers and car equipments, for the Sao Paulo Tramway, Light & Power Co., Brazil; and a 200 kw. generator, with transformers and induction motors, for the Inca Mining Co., Peru. Several of the orders for these equipments have been reported in the Review.

A Modern Suburban Light & Power Plant

(Elec. Wld., Aug. 4, 1906, p. 219)

The plant of the Quincy, Mass., Electric Light & Power Co. is one of the most modern in the vicinity of Boston. Its structure and equipment are of interest more by reason of their general high quality of design rather than on account of any especially novel features. This station was laid out a year ago for an initial equipment of 450 kw., with room for an ultimate capacity of 1250 kw. which is now required by increasing business. The electrical equipment, which is of General Electric make, comprises one 150 kw., one 300 kw. and one 800 kw. 2300 volt three-phase generators, a 20 kw. "marine set" exciter, two 125 volt motor generator exciters, a TA regulator, and one 100 kw. and five 30 kw. transformers.

The Power Plant of the Western New York & Pennsylvania Traction Co.

(Elec. Wld., Aug. 4, 1906, p. 204)

This Company, which operates one hundred miles of track between Olean and Salamanca, N. Y., and Bradford, Pa., is building a new generating station, to contain four 500 h.p. gas engines operated by natural gas, direct connected to 300 kw., 25 cycle, three-phase generators. The station equipment also includes two motor driven pumps for supplying cooling water, and two exciters driven by 85 h.p. gas engines. The main generators operate at 2300 volts, supplying current to a 300 kw. rotary converter for local distribution, and to transformers which step up the voltage to 22,000 for transmission to four sub-stations. The entire electrical equipment of the generating station and sub-stations is being furnished by the General Electric Company.

The Electrical Plant of the Canadian Niagara Power Company

[Elec. Rev., July 14, 1906, p. 53]

A well written article describing the first plant for the electrical generation of power to be designed and to have construction work done upon it on the Canadian side of Niagara Falls. The present plant consists of five 10,000 h.p., 12,000 volt General Electric generators, an operating board of five generator panels, twenty feeder panels and three bus bar interconnecting panels. In case additional generators are added they will have an entirely separate board. The exciter plant contains three 200 kw., 125 volt direct current generators. There are twelve 1250 kw. transformers. Transmission lines, the construction of which is described in detail, extend to Buffalo and to the Niagara Falls Power Company's plant.

The Hydro-Electric Plant of the Baker Light & Power Co., Baker City, Ore.

[Elec. Rev., July 7, 1906, p. 10]

This plant is supplied from a rapid mountain stream seventeen miles northwest of Baker City through a flume one and a quarter miles long. Two water wheels, developing 750 h.p. each and direct connected to 400 kw. revolving field, 60 cycle, 2300 volt, three-phase General Electric generators, equipped with TA regulators, are at present installed, and room is provided for a third unit. Interesting details are given of the transmission lines, of which there are two: one running to Baker City, seventeen miles distant, and the other to Bourne, thirteen miles distant. The lightning arresters are of the General Electric multiplex type. Illustrations are given of the power house and equipment.

The Power Plant of the Electrical Development Company of Ontario

[Elec. Rev., July 28, 1906, p. 138]

A paper read by Mr. F. O. Blackwell before the Canadian General Electric Association. The construction of this plant, which is located at Tempest Point on the Niagara River, involves some new and original ideas, one of them being a tailrace tunnel which discharges under the Horseshoe Fall. The water wheels are of 13,000 kw. capacity, running at 250 rev. per min., and are connected to the generators by 150 ft. hollow vertical shafts of special construction. Four of the ultimate equipment of eleven 8000 kw., 250 rev. per min., revolving field generators, two 500 kw. water-wheel driven exciters and two 500 kw. motor generator exciters are now being installed by the Canadian General Electric Company. The transformer house is built to accommodate fifteen 2670 kw. transformers furnished by the Canadian General Electric Company, twelve of which are now being installed. The hydraulic construction, switchboard, station wiring, and transmission lines are described in detail.

Spier Falls Power House

[Elec. Rev., July 21, 1906, p. 91]

Although the power house at Spier Falls is the largest of several generating stations operated by the Hudson River Electric Power Company, it is least known on account of its secluded location. The entire electrical equipment was built by the General Electric Company and includes six large units—four of 2500 kw., and two of 2000 kw. capacity—and a unit of 300 kw. capacity. The generated voltage is 2000, and the frequency 40 cycles. There are four three-phase transmission lines, extending respectively to Glens Falls, Ballston and Schenectady. The article is illustrated by views of the plant, and contains interesting data on the hydraulic equipment.

The Plant of the Great Northern Power Company of Duluth, Minn.

[Elec. Wld., July 28, 1906, p. 171]

This illustrated article describes a typical example of the present tendency in electric power station design to employ very large generating units rather than a number of small units. This Company's power scheme, when fully carried out, will call for the transmission of 200,000 h.p. The plant now under construction will have an initial equipment for the generation of 30,000 h.p., to be transmitted from the generating station on the St. Louis River to Duluth and Superior over two steel tower lines. Three 7500 kw., 375 rev. per min., three-phase, 25 cycle, 6600 volt, vertical shaft water wheel driven generators, with complement of water wheel driven and motor driven exciters, are now being installed. For stepping up the generator voltage to the line voltages of 30,000 and 60,000, three transformers, each of 7500 kw. capacity, of the "forced oil"* type, are now being installed. The entire electrical equipment, including an elaborate but compact switchboard with remote control oil switches, is furnished by the General Electric Company.

The Operation of Cars in Trains at Columbus

[St. Ry. Jour., June 30, 1906, p. 1010]

In order to avoid congestion during rush hours, the Columbus Railway & Light Co. has adopted the plan of running trains of two two-motor cars. The forward car is equipped with Sprague-General Electric type M control for four motors, and the rear car with K-10 controllers, and the wiring systems of the two cars are connected by jumpers. The illustrations include views of the couplings and a diagram of the wiring systems.

Improvements and Operating Features of the Southwestern Missouri Electric Railway

(St. Ry. Jour., July 21, 1906, p. 92)

On account of the development of the zinc and lead mines around Joplin, Mo., traffic over this road has increased, necessitating double tracking and the building of a 10-mile extension. A number of heavy interurban cars, designed and built at the Company's shops, are fully described and illustrated. These cars are equipped with four GE-70 motors and Sprague-General Electric type M control, and with lightning arresters with forty six-turn reactive coils. A good part of the article is devoted to the policy of the Company toward its employees, the system of conductors' reports, and similar details.

Single-Phase Railway for Anderson, S. C.

[Elec. Wld., July 21, 1906, p. 121]

A brief article describing the interurban line which the Anderson Traction Company is building, to extend eventually to Glenville, a distance of thirty-five miles. Complete apparatus has been ordered from the General Electric Company for single-phase operation, including 75 h.p. single-phase motors operating at 3300 volts A.C. and 550 volts D. C., fitted with air brakes with A. C.—D. C. motor driven compressors, for equipping heavy interurban cars. At the Anderson sub-station there is to be installed a three-unit motor generator set consisting of an induction motor, taking power from the Savannah River Power Company, direct connected to an A. C. generator for supplying the single-phase portion of the road, and to a D. C. generator for supplying the present city line.

Electrical Notes from Europe

[Elec. Rev., July 14, 1906, p. 59]

EXPERIMENTAL SINGLE-PHASE RAILWAY AT PARIS

A brief account of tests now under way by the French Thomson-Houston Co., using a trolley voltage of 500 and cars equipped with two 300 volt, four-pole, 50 h.p. motors. Potential control is employed, using taps on the secondary of a transformer carried under the car body.

CAGNES-MENTON TRAMWAY

A brief description of the 30-mile narrow gauge electric tramway running between Cagnes and Menton, France. Current at 550 volts is supplied by sub-stations which receive current at 10,000 volts from a hydraulic plant. Each sub-station contains two 250 kw. motor generator sets, a battery of 281 storage cells and a 35 kw. booster group, supplied by the French Thomson-Houston Company.

The East River Tunnels for the New York City Terminus of the Pennsylvania and Long Island Railroads. II.

[Eng. Rec., July 21, 1906, p. 66]

The second of a series of articles describing the mechanical equipment of these tunnels. The various shops of the contracting companies, at the New York end of the tunnels, are equipped with General Electric motors driving line shafts to which various tools are belted, the motors being supplied with current by three 25 kw. General Electric generators installed at the East 33d Street yard. The electrical installation is typical of the flexibility of electric power distribution for contractors' work.

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*See article by Mr. W. S. Moody in the May, 1906, Review entitled "High Voltage Transformers of Large Capacity".

General Electric Company Review, August, 1906

INDEX

Page

Abstracts of Important Technical Articles 69

Europe, Electrical Notes from 70

Generating Systems:
  Suburban Light & Power Plant, A Modern 69
  (See also "Machinery," "Traction" and "Transmission")

Glue Pots, Electric (see "Heating Devices").

Heating Devices:
  Glue Pots, Electric, by F. M. Vogel & H. J. Mauger .. 66

Machinery, Electrical, in South America 69

Motor Drive (see "Tunnels").

Recent Important Sales 60

Regulator, Type BR Feeder, Performance of Recorded by Thomson Curve Drawing Voltmeters, by George Rockwell, Jr. 57

Sewerage Plant for the City of Salem, Mass. 63

Switch, Rheostat, Solenoid Operated Remote Control, by W. C. Yates 59

Traction:
  Cagnes-Menton Tramway 70
  Single-phase Railway at Paris, Experimental 70
  Single-phase Railway for Anderson, S. C. 70
  Southwestern Missouri Electric Railway, Improvements and Operating Features of the 70
  Trains, The Operation of Cars in, at Columbus 70
  Western New York & Pennsylvania Traction Co., The Power Plant of the 69
  (See also "Machinery")

Transmission:
  Baker Light & Power Co., Baker City, Ore., The Hydro-Electric Plant of the 69
  Canadian Niagara Power Co., The Electrical Plant of the 69
  Electrical Development Co. of Ontario, The Power Plant of the 69
  Great Northern Power Co. of Duluth, Minn., The Plant of the 70
  Spier Falls Power House 70
  (See also "Traction")

Tunnels, The East River, for the New York City Terminus of the Pennsylvania and Long Island Railroads, II 70

Turbine, Steam, An Investigation of the 69

RECENT INSTALLATIONS, CONTRACTS AND SALES

		Page
Ajax Metal Co.	Philadelphia, Pa.	61
American Smelters Securities Co.	New York, N. Y.	62
Anderson Traction Co.	Anderson, S. C.	70
Ansonia Mfg. Co.	Ansonia, Conn.	60
Baker Light & Power Co	Baker City, Ore.	69
Bethlehem Steel Co.	South Bethlehem, Pa.	61
Birmingham Ry., Light & Power Co.	Birmingham, Ala.	60
Boston Consolidated Mining Co.	Salt Lake City, U.	62
Canadian General Electric Co.	Toronto, Ont.	69
Canadian Niagara Power Co.	Niagara Falls, Ont.	69
Clara Mfg. Co.	Gastonia, N. C.	61
Chicago Edison Co.	Chicago, Ills.	62
Columbus Ry. & Light Co.	Columbus, O.	70
Copper Queen Consolidated Mining Co.	New York, N. Y.	60, 62
Corps of Engineers, U. S. Army	Washington, D. C.	61
Crocker Co., H. S.	San Francisco, Cal.	62
De Laval Steam Turbine Co.	Trenton, N. J.	60
Edison Electric Co.	Los Angeles, Cal.	62
Edison Electric Ill'g Co.	Williamsport, Pa.	61
Empresa Electrica de Santa Rosa	River Rimas, Peru	69
Enterprise Mfg. Co.	Philadelphia, Pa.	62
Everett Mills	Lawrence, Mass.	60
Ford, Bacon & Davis	Memphis, Tenn.	60
French Thomson-Houston Co.	Cagnes-Menton, France	70
French Thomson-Houston Co.	Paris, France	70
General Electric Co.	Lynn, Mass.	68, 69
General Electric Co.	Schenectady, N. Y.	69
General Vehicle Co.	Long Island City, N. Y.	60
Ginn & Co.	Cambridge, Mass.	67
Great Northern Power Co.	Duluth, Minn.	70
Holyoke Machine Co.	Holyoke, Mass.	60
Hudson River Electric Power Co.	Glens Falls, N. Y	60
Hudson River Electric Power Co.	Spier Falls, N. Y.	70
Inca Mining Co.	Peru	69
Ingersoll-Rand Co.	Phillipsburg, N. J.	60
Joslyn Mfg. Co.	South Scituate and Hope, R. I.	60
Kistler Stationery Co., W. H.	Denver, Colo.	62

		Page
Long Island Electric Ry. Co.	Long Island City, N. Y.	60
Long Island R. R. Co.	New York, N. Y.	70
Manhattan Mining & Power Co.	Twin Lakes, Colo.	62
Memphis Street Ry. Co.	Memphis, Tenn.	60
Minneapolis General Electric Co.	Minneapolis, Minn.	61
Monarch Cotton Mills Co.	Dallas, N. C.	61
Morse Bros. Machinery & Supply Co.	Denver, Colo.	62
New York City Ry. Co.	New York, N. Y.	60
New York Edison Co.	New York, N. Y.	60
Niagara Falls Power Co.	Niagara Falls, N. Y.	69
Northern Electric Co.	Chico, Cal.	62
Pennsylvania R. R. Co.	New York, N. Y.	70
Pittsburg, Harmony, Butler & New Castle Street Ry. Co.	Pittsburg, Pa.	61
Pressed Steel Car Co.	McKees Rocks, Pa.	62
Quincy Electric Light & Power Co.	Quincy, Mass.	69
Reading Iron Co.	Reading, Pa.	62
St. Louis Car Co.	St. Louis, Mo.	62
Salem City Council	Salem, Mass.	63
Sao Paulo Tramway, Light & Power Co.	Sao Paulo, Brazil	69
Savannah River Power Co.	Anderson, S. C.	62, 70
Southwestern Missouri Electric Ry. Co.	Joplin, Mo.	70
Spencer Mountain Mills	Lowell, N. C.	62
Stone & Webster	Boston, Mass.	61
Tampa & Sulphur Springs Traction Co.	Tampa, Fla.	62
Tholen Bros.	Leavenworth, Kas.	62
United Railways of San Francisco	San Francisco, Cal.	62
Utah Copper Co.	Garfield, U.	62
Virginia-Carolina Chemical Co.	Charleston, S. C.	62
Washington Water Power Co.	Spokane, Wash.	62
Watkins & Co., J. W.	San Francisco, Cal.	62
Weidenthal-Gosliner Electric Works	San Francisco, Cal.	62
Western New York & Pennsylvania Traction Co.	Olean, N. Y., Bradford, Pa.	69
Western Union Telegraph Co.	New York, N. Y.	62
Yamhill Electric Co.	Newburg, Ore.	62

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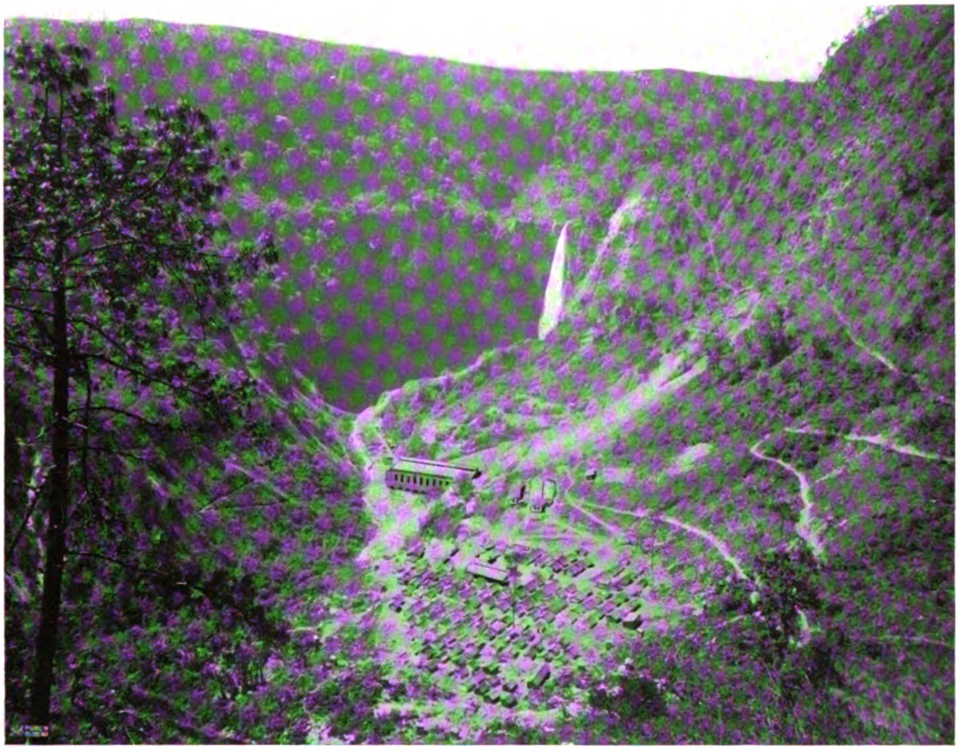
GENERAL ELECTRIC COMPANY REVIEW

Vol. VII SCHENECTADY, N. Y., SEPTEMBER, 1906 No. 5

THE NECAXA TRANSMISSION, MEXICAN ELECTRIC LIGHT & POWER CO.

The Review for July, 1904, contained an illustrated article by Mr. Fred M. Kimball entitled "The Greatest Development of Water Power in Mexico," in which this transmission scheme, which constitutes the longest direct electric power transmission in the world, was fully described. The approaching completion of this great enterprise, which is going to mean so much for the material development of Mexico, attracts special attention at the present time.



The Lower Necaxa Falls, Power House and Construction Camp
Taken from the French trail above, where water from Necaxa dam spillway will discharge

Generating Plant

The power station is located at Necaxa, about 100 miles northeast of the City of Mexico. The main receiving stations are in Mexico City and at El Oro, a mining camp located about 75 miles from Mexico City, making the total length of transmission from Necaxa to El Oro about 174 miles.

Work at Necaxa was actually begun in the summer of 1903. At the present writing there are in operation at the Necaxa power plant three of the 5000 kw., 4000 volt, 50 cycle, three-phase revolving field generators out of the ultimate total of six of these units. The third unit was put into service in April of the present year, while the first unit was put into service in December, 1905, and immediately began supplying 70 per cent of the power used at that time in the City of Mexico and El Oro. With two generators running, the Curtis steam turbine-generator plant in the City of Mexico, which has been installed as a reserve to the main transmission from Necaxa, was called upon to furnish only 12 per cent of the power; and the three Necaxa generators now in service will be taxed to their utmost capacity to take care of the present load, which is increasing so rapidly that it promises to more than keep pace with the capacity of the Necaxa plant as additional units are installed.

Transmission Line

The transmission line transverses almost all conditions of country, so that the atmospheric conditions are very unfavorable. It goes for miles through valleys at relatively low altitude, then abruptly climbs high mountains, proceeding on top of these mountains, descending again, crossing other mountains, etc. Moreover, at the rainy season the line is subjected to thunder storms of more or less violent nature practically every day.

From the Necaxa power house two independent lines of steel towers lead to Mexico City and from there one line of steel towers leads to El Oro. Each tower line has two independent sets of conductors, so that from Necaxa to Mexico City there are four transmission lines, each consisting of three wires. The lowest conductors are 40 ft. above the ground. The towers are 50 ft. high, sets 5 ft. in the ground, and cost $60 each. The standard length of span is about 500 ft., although some spans are much longer—1500 ft. in one instance where the line has a vertical drop of 450 ft. At another place, where the line has a vertical drop of 850 ft., the towers are 1300 ft. apart. The conductors are standard copper cables having a cross section equivalent to No. 000 wire, B. & S. gauge, and are placed 6 ft. apart. Two types of insulators are used, 14½ in. and 17½ in. in diameter, respectively, made in three sections and tested at 120,000 volts before being put on the line. The pins are of iron, 15 in. high. No trouble has been experienced with any of the mechanical features of the line.

General Electric Company Equipment

The General Electric Company has furnished the entire equipment of switching apparatus at Necaxa, the City of Mexico and El Oro, the four 500 kw. Curtis steam turbine-generators at the City of Mexico generating station, and the following 50 cycle step-up and step-down transformers, comprising the entire transformer equipment for this transmission:

At Necaxa: Five banks of three 2000 kw. type WC single-phase step-up transformers. These transformers receive current at the generator potential of 4000 volts and by means of taps in the high tension side deliver energy to the line at 40,000, 50,000 or 60,000 volts. At the present time nine of these transformers are in service, stepping up to a line voltage of approximately 47,000 volts.

At the City of Mexico: Twenty 1800 kw. type WC transformers, arranged in three groups for stepping down the line voltage to 19,000 for distribution for power purposes in the vicinity of the City of Mexico, and to 6,000 and 3,000 volts for distribution within the city proper for operating the tramway and lighting systems and for power purposes.

At El Oro: Four 1800 kw. type WC transformers for stepping down to 6,000 and 3,000 volts for power and lighting at the mines.

Complete General Electric Company lighting arrester equipments have been installed on the transmission lines in the power house at Necaxa and at Mexico City.

MULTIPLE D.C. LUMINOUS ARC LAMP

By G. N. Chamberlin

The General Electric Company has recently placed on the market a D.C. 110 volt (nominal) multiple luminous arc lamp, shown in the accompanying illustrations, Figs. 1 and 2, very similar in design to the well known D.C. series luminous arc lamp and possessing the same advantages over the enclosed carbon arc.

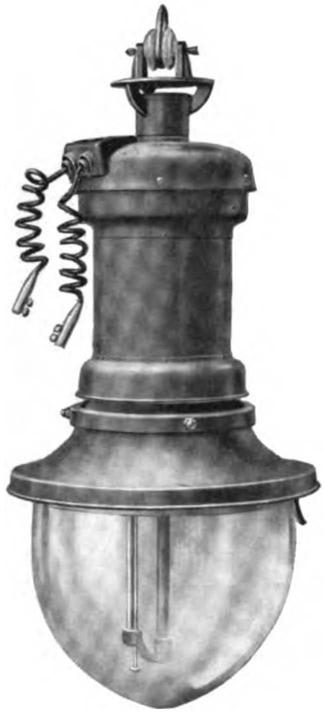


FIG. 1
5 Amp., 110 Volt D.C. Multiple Luminous Arc Lamp

Illumination

The D.C. multiple luminous arc lamp, operating at 5.0 amp., gives considerably higher candle-power than an enclosed carbon arc operating on the same circuit at the same wattage, and has the further advantage that its axis of maximum light distribution is at an angle of 10 deg. below the horizontal, giving an ideal distribution for street lighting, throwing the light where it is required, rather than banking it beneath the lamp where there is always sufficient light.

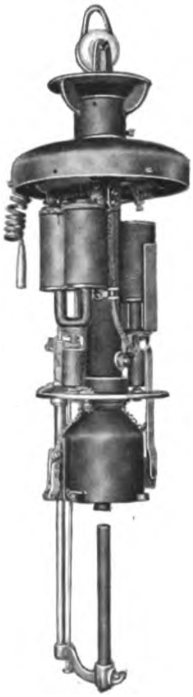


FIG. 2
5 Amp., 110 Volt, D.C. Multiple Luminous Arc Lamp

The focusing feature of the lamp makes it possible to use a small internal reflector directly above the arc, thus giving the most efficient reflection at an acute angle.

Connections and Operation

By reference to the diagram of connections, Fig. 3, it will be seen that the connections of the arc lamp are very simple, the shunt coil being in circuit only when lifting the lower electrode. At other times only the series regulating magnet and the regulating resistance are in circuit.

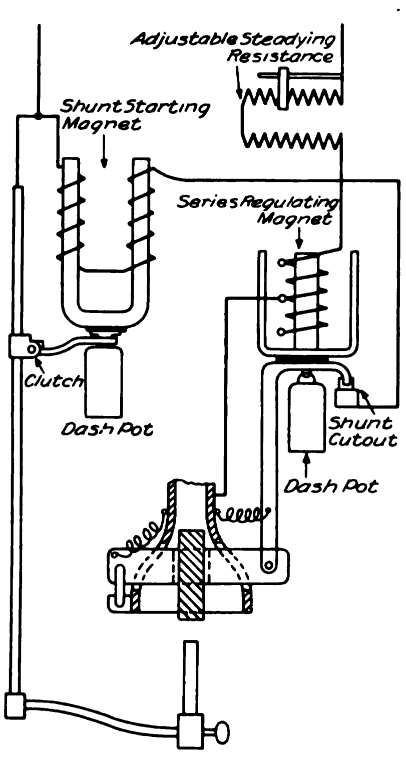


FIG. 3
Connections of D.C. Multiple Luminous Arc Lamp

The operation of the lamp is as follows:

Starting with the electrodes apart, when current is thrown on the lamp the shunt magnet is energized, bringing the two electrodes together. As soon as the electrodes come together the current takes the easier path, energizing the series regulating magnet, which strikes the arc and opens the shunt circuit at the cut-out contacts. The lamp then burns and regulates like an ordinary multiple lamp with series magnet and resistance only.

Electrodes

The upper or positive electrode is a bar of hard drawn copper supported by iron wings (see Fig. 3). On account of the mass of the copper in the electrode and the properties of the luminous arc, the electrode wears away very slowly, requiring renewal only after three or four thousand hours' operation. Thus with an average burning of five hours per day an upper electrode will last for two years or more.

The characteristic flaming arc of this lamp is obtained by the use of a specially prepared composition as the negative electrode of the arc. The electrode consists of an iron tube ⅝ in. in diameter and 8 in. long, filled with the composition and having a life of 100 to 150 hours. Only one electrode is used at each trimming.

Adjustment

The adjustment of the lamp is similar to that of the series lamp and quite simple. The position of the arc is controlled by the adjustable stop which is located on the left hand guide rod within the lamp casing. An arc voltage of approximately 75 volts is obtained by adjusting the amount of series resistance connected in the circuit, and the current is maintained constant by the series regulating magnet.

The lamp at the present time is designed to operate either on 4.0 or 5.0 amp. When operating at 4.0 amp. it still gives a light in excess of the 5.0 amp. carbon arc. For the present the lamps will be manufactured for operation on these two currents only. The resistance is of the edgewise type, placed within the lamp mechanism, and has sufficient leeway for operating lamps at 4.0 or 5.0 amps., and 110 to 125 volts.

The lamp is furnished with solid copper casing and closed base globe, and is substantial in construction as well as pleasing in appearance. In general the lamp needs less attention than the enclosed arc, as there are no inner globes and gas caps to require special handling, cleaning and renewing. At every trimming it is necessary to thoroughly clean the center or draft tube of the lamp as well as the box containing the upper electrode. This cleaning is easily done by a small brush provided for the purpose. The lower electrode in burning gives off reddish brown fumes, leaving a deposit of ash in a small pan which is provided at the bottom of the lamp and which can easily be emptied at each trimming. A certain percentage of the fumes go up into the draft tube and escape into the air, practically prohibiting the use of the lamp for many indoor installations where such fumes are objectionable: for example, in clothing stores, underneath white ceilings, etc.

The lamp is furnished with leading-in cables fitted with suitable terminals, marked on the lamp top positive and negative, to facilitate the connecting of the lamp with the proper polarity. Should the lamp be operated with the lower electrode positive, instead of the upper one, it will burn with a low efficiency copper arc which will be continually rupturing, and which will cause a very rapid disintegration of the upper electrode.

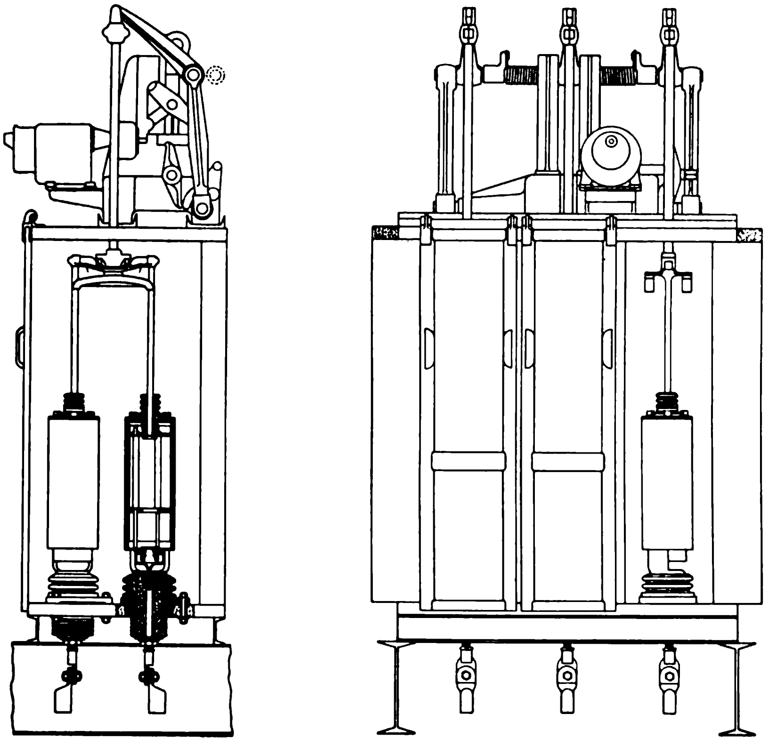


FIG. 1

Type F, Form H-3, 800 Amp., 15,000 Volt, T.P.S.T. Oil Switch

REMOTE CONTROL OIL BREAK SWITCHES

By H. L. Smith, Switchboard Engineering Dept.

In making up the layout for the electrical equipment of modern stations it is often found necessary or desirable to mount the oil break switches at a considerable distance from the switchboard. This applies to low tension, small capacity oil switches, which for convenience may be mounted on a framework remote from the panel, as well as to high tension oil switches which are almost always mounted in fireproof cells.

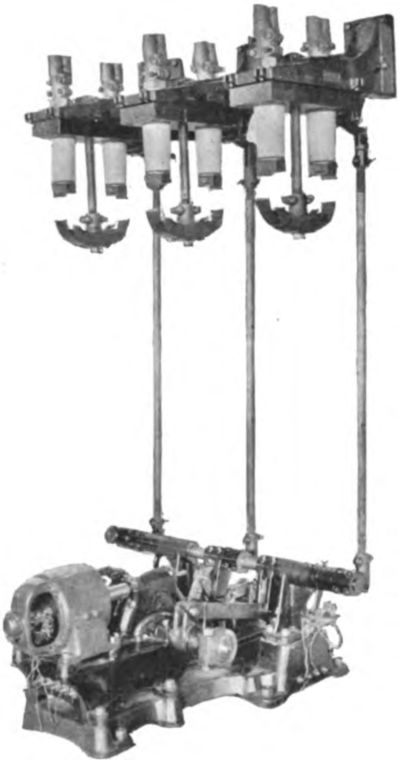


FIG. 2
Motor Operated, T.P., 2500 Volt, 1500 amp. Oil Switch

For the control of circuits having large station capacity back of them, the well known form H motor operated oil switches have been in use for some time. The accompanying illustration, Fig. 1, shows a section and front view of a form H-3 motor operated oil switch. These switches are built in many sizes for voltages ranging from 2500 to 60,000 and to carry from 100 to 3000 amperes. All of these switches are built in cells and are operated by D.C. motors which form an integral part of the switch mechanism.

Where remote control form K oil switches are installed, the following forms of operating mechanism are used:

1. Mechanical remote control mechanism, in which the switches are operated from a lever upon the switchboard through a series of bell-crank levers and connecting rods of wrought iron pipe or wood. With manual remote control the distance of the oil switch from the operating panel is limited to about ten or fifteen feet.

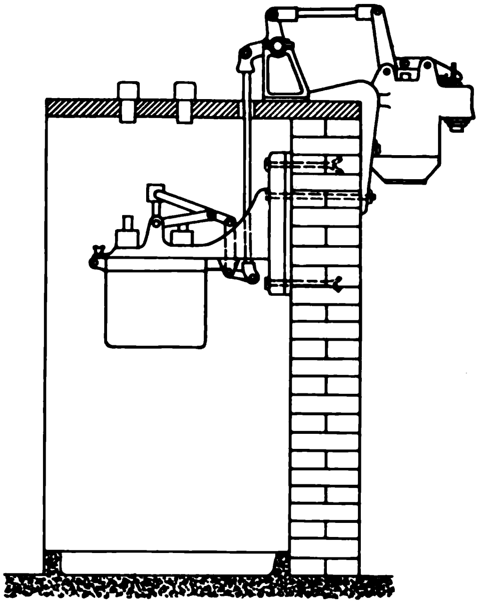


FIG. 3
Solenoid on Back of Cell with Mechanism on Top, Operating Three S.P.S.T., Type F, Form K-4 Oil Switches in Cell

2 D.C. electrically actuated remote control mechanisms, in which the switches are operated by a D.C. motor or solenoid mounted near the oil switch and mechanically connected to it by a minimum number of rods and bell-cranks. The circuit to the

motor or solenoid is connected through a small controlling switch mounted upon the switchboard panel or benchboard.

With electrical remote control the distance of the oil switch from the panel is limited only by the voltage drop in the control wire circuit. This method of operation has the additional advantages that no manual effort is required to close or open the oil switches, and the oil switches can be closed much more quickly than by hand; while the station arrangement is often greatly simplified and the size of the switchboard reduced to a minimum, thereby effecting a general economy of space. Both the motor mechanisms and solenoid mechanisms require direct current to operate them. The direct current can usually be obtained from the station exciter busses. Both forms of operating mechanism may be connected to circuit closing relays, to open the oil switches automatically on overload.

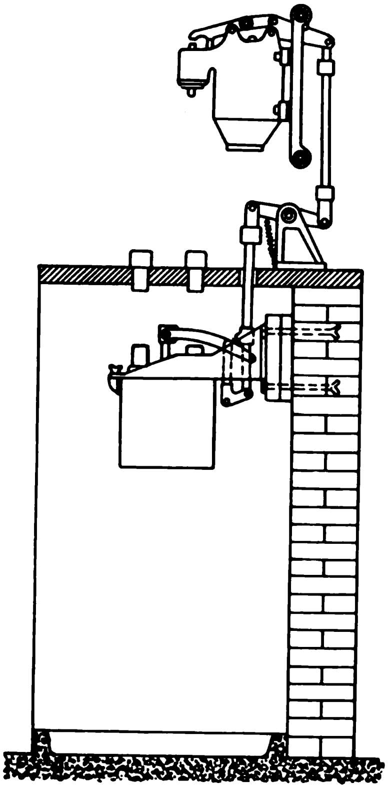


FIG. 4

Solenoid on Pipe Frame Work Above Mechanism on Top of Cell for Operating Three S.P.S.T., Type F, Form K-2 Oil Switches in Cell

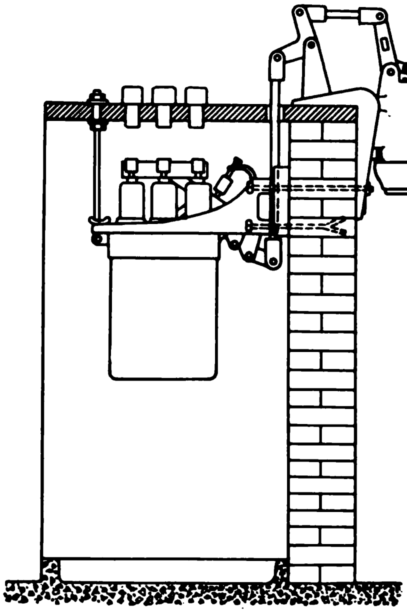


FIG. 5

Solenoid on Back of Cell with Mechanism on Top, for Operating T.P.S.T., Type F, Form K-4 Oil Switch in Cell

Motor operated mechanisms have been in very general use for some time, and their construction and operation are fairly well known. In these devices the motor operates the switch indirectly: being used to store up energy in a spring, which performs the required work when released by the controlling circuit. These mechanisms are therefore especially adapted for synchronizing, and for heavy work as, for example, in the case of the 2500 volt, 1500 amp. oil switch, a view of which is given in Fig. 2.

The solenoid operated mechanism is a later development, and has met with favor as it effects a greater economy of space and is somewhat simpler in construction and operation. In this mechanism a large plunger, actuated by the main solenoid winding, imparts a definite motion to a short, powerful toggle. The movement of the toggle is transmitted to a bell-crank, which may be extended as desired to obtain the required travel for the proper operation of the switch. The solenoid mechanism includes, in addition to the main coil, a small tripping coil actuating a plunger which breaks the toggle and allows the switch to open.

A number of different sizes of solenoids have been developed to suit the varying requirements of the several kinds of form K oil switches. All solenoid mechanisms are equipped with S.P.D.T. auxiliary switches which may be used for lamp indication, for opening the trip coil circuit or for electrically interlocking two solenoids.

The solenoid is usually mounted on the back of the switch cell with the switch operating mechanism on top of the cell, as shown in Figs. 3 and 5, on a pipe framework above the cell (Fig. 4) or on a separate pipe framework from that supporting the oil switch. (Fig. 6.)

Solenoid mechanisms are made for operating either double-pole, triple-pole or four-pole switches, or combinations of single-pole switches, as shown in Figs. 3 to 6, inclusive. Special combinations have been made with oil switches and solenoids mounted on a common base casting as in the cases of the solenoid operated oil switches for the Chicago Edison Co., shown in the annexed views, Figs. 7 and 8.

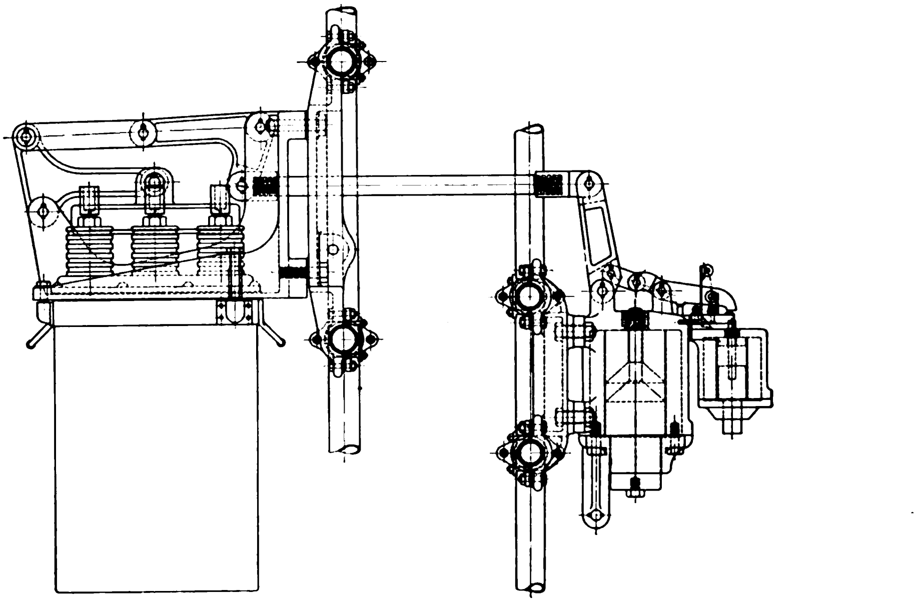


FIG. 6

500 Amp., 15,000 Volt, T.P.S.T. Form K-2 Solenoid Operated Oil Switch Mounted on Pipe Framework

Among companies which have installed large equipments of solenoid oil switch operating mechanisms may be mentioned the following:

Omaha Electric Light & Power Co., Omaha, Neb.

Mexican Light & Power Co., Mexico City, Mex.

Winnipeg General Power Co., Winnipeg, Manitoba.

Tokio Electric Light Co., Tokio, Japan.

Chicago Edison Co., Chicago, Ills.

New York Edison Co., New York, N. Y.

Indianapolis Light, Heat & Power Co., Indianapolis, Ind.

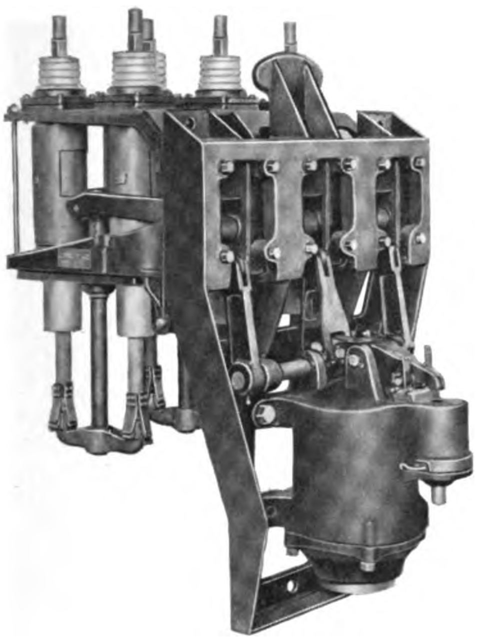


FIG. 7

Three S.P., 15,000 Volt, Type F, Form K-2 Oil Switches Operated by One Solenoid, with Disconnecting Devices

Cleveland Electric Illuminating Co., Cleveland, O.

Great Northern Power Co., Duluth, Minn.

Union Light, Heat & Power Co., St. Louis, Mo.

RECENT IMPORTANT SALES

New York Office

ONEONTA & MOHAWK VALLEY R. R. CO.,
ONEONTA, N. Y.

For Oneonta & Mohawk Valley R. R. Co., Oneonta, N. Y.
One 300 kw. rotary converter.
One rotary starting rheostat.
Three 110 kw. AB transformers.
One 2 h.p. blower set.
Four switchboard panels.

BUFFALO FORGE CO., BUFFALO, N. Y.

Eleven 25 cycle, 750 rev. per min., 440 volt, form K induction motors, ranging from 4 to 60 h.p., and aggregating 265 h.p.

Four 440 volt form K induction motors, aggregating 2750 h.p.

Two H 25-100-2200-488/244 volt transformers.

One Buffalo line panel for transformers.

CONSOLIDATED RY. CO., POWNAL CENTER, VT.

Two TC 4-200-750-600 volt, compound wound, 25 cycle rotary converters.

Two 30 KVA oil cooled reactive coils.

Six H 25-75-11000/22000-370 volt step-down transformers.

Eight switchboard panels.

Lightning arrester.

DUNKIRK & FREDONIA R. R. CO., FREDONIA, N. Y.

Six two-motor GE-87 car equipments, with K-11 controllers.

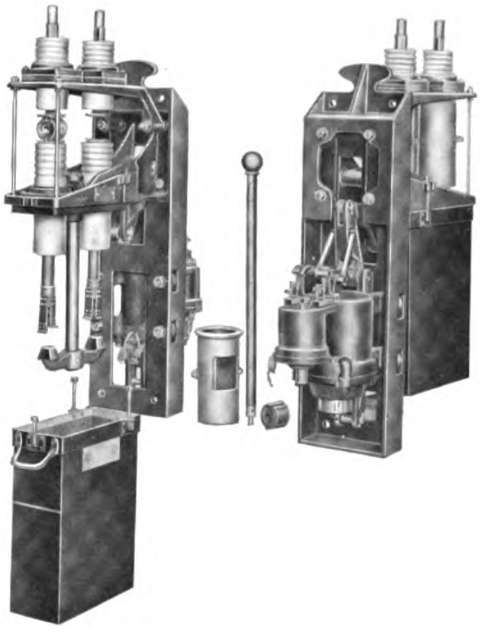


FIG. 8

Solenoid Operated 300 Amp., 15,000 Volt, Type F, Form K-2 Oil Switch, with Disconnecting Device

DUNKIRK STREET RY. CO., DUNKIRK, N. Y.

Four two-motor GE-80 standard equipments, with K-10 controllers.

DELAWARE, LACKAWANNA & WESTERN R. R. CO.,
NEW YORK, N. Y.

Apparatus for Pennsylvania plants, as follows:

For Kingston:

Four GE-51 series wound railway motors.

For Holden Colliery:

One HC 8-200-900-275 volt rotary converter.
Three H 60-75-4400-208 volt transformers.
One switchboard.

For National Colliery:

One HC 6-200-900-275 volt rotary converter.
Three H 60-75-4400/2200-208 volt transformers.
One switchboard.

For Nanticoke:

Three I 14-200-514-440 volt form M induction motors.

For Scranton:

Two I 16-150-450-440 volt form M induction motors.

ELECTRIC VEHICLE CO., HARTFORD, CONN.

Fifty-one S-34-0 automobile controllers with resistances.

One hundred GE-1020, 85 volt, 20 amp., 2000 rev. per min., back geared automobile motors.

The above are for use on broughams sold by this company to the New York Transportation Company for use in New York City. The New York Transportation Company has about five hundred electric vehicles in service in New York City.

HAMBURG RY. CO., BUFFALO, N. Y.

Twelve two-motor GE-87 car equipments, with K-11 controllers.

HUDSON RIVER ELECTRIC POWER CO.,
GLENS FALLS, N. Y.

Thirteen 60 cycle, form L, riveted type induction motors, of 6, 12 and 22 h.p., 1200 rev. per min., 550 volt.

Four 40 cycle, form L, riveted type induction motors, of 30 and 40 h.p., 800 rev. per min., 550 volt.

INTERNATIONAL PAPER CO., NEW YORK, N. Y.

For Livermore Mill, Riley, Me.

One ATB 16-300-450-2300 volt generator.
One CQ 4-(11 kw.)-1250 volt exciter.
One switchboard.
Six type H transformers, aggregating 165 kw. capacity.
Wire, arc lamps and supplies.

MEMPHIS STREET RY. CO., MEMPHIS, TENN.

Four four-motor GE-80 car equipments with K-28 controllers.

MURRAY ELECTRIC LIGHT & POWER CO.,
MONTICELLO, N. Y.

One ATB 28-100-900-2300 volt generator.
One 3 1/2 kw. exciter.
One Cat. No. 32516 K-3 oil switch.
Twenty-two 1200/2400-120/240 volt transformers, aggregating about 82 kw.
Lightning arresters.
Sixty indicating wattmeters.

NEW YORK CLUB, NEW YORK, N. Y.

For Club Building.

One MP 6-75-250 three-wire form R generator.

Two MP 6-50-265 three-wire form R generators.

NEW YORK EDISON CO., NEW YORK, N. Y.

One AB 25-800-6300-170 volt transformer.

One IRH 4-300-25-170-3600 induction regulator.

ANDREW J. ROBINSON & CO., NEW YORK, N. Y.

For Mayfair Apartment House, New York, N. Y.

Three MP 6-60-280 generators, with compensator for three volt unbalancing, extra brushes.

For Hyde Park Mine, Scranton, Pa.

One HC 12-600-600-275 volt rotary converter.
One switchboard.

For Woodward Colliery, Kingston, Pa.

Two HC 8-200-900-275 volt rotary converters.
One switchboard.

For Pyne Mines, Taylor, Pa.

One HC 12-300-600-275 volt rotary converter.
One switchboard.

TRACTION ENGINEERING CO.

For Olean, N. Y.

Six four-motor GE-80 car equipments.

UNITED RAILROADS OF SAN FRANCISCO,
SAN FRANCISCO, CAL.

Two four-motor GE-90 car equipments with K-28 controllers.

Philadelphia Office

AMERICAN PLATE GLASS CO., KANE, PA.

Eight 175 h.p., 550 volt induction motors.
Six 300 h.p., 550 volt induction motors.

BARNES & TUCKER CO., BARNESBORO, PA.

One ATB 36-240-200-2300 volt generator with direct connected exciter.

The above firm is engaged in mining, but the apparatus sold them is to be used in lighting the towns of Barnesboro, Spangler and Cherry Tree, Pa.

CARBON COAL CO., LANGDONDALE, PA.

One CL 6-100-550-B-250 volt generator.
Switchboard.
One LM 106-C-1, 38 in. gauge mining locomotive.
Miscellaneous wiring and supplies.

DELAWARE, LACKAWANNA & WESTERN R. R. CO.,
NEW YORK, N. Y.

For Scranton, Pa.

Two LM 101-M-2, 6 1/2 ton mining locomotives.

Twenty-two LM-101-L-1, 6 1/2 ton mining locomotives.

One LM 102-A-2, 10 ton mining locomotive.

One LM 104-B-1, 10 ton mining locomotive.

These twenty-six mining locomotives are duplicates of a large number already in service in the various collieries of this company, and represent approximately the number of electric locomotives that are added each year.

Two 500 kw. Curtis steam turbine-generators.

Five rotary converters, aggregating 1400 kw., with transformers and switchboards, for mine work.

Sale made by New York Office.

E. I. Du Pont Co., Wilmington, Del.

For Laflin & Rand Powder Co., Oriental Siding, Fairchance, Pa.

Six 440 volt motors, aggregating about 237 h.p.

Erie Electric Motor Co., Erie, Pa.

Thirteen two-motor GE-87 car equipments, with K-11 controllers. Sale made by New York Office.

Fairmont Coal Co., Fairmont, W. Va.

For Glenfalls, W. Va.

Six 150 kw. 225 volt rotary converters.

Six 110 kw. 185-22,000 transformers.

Six 55 kw. transformers.

Switchboard panels, lightning arresters, etc.

Hanley-Casey Co., Chicago, Ills.

For Municipal Building, Washington, D. C.

One MP 6-75-275-225/240 volt form L generator.

Two MP 8-150-220-225/240 form L generators.

These machines are to be used for lighting and power.

New England Engineering Co., Waterbury, Conn.

For Nazareth Portland Cement Co., Nazareth, Pa.

Fifteen 550 volt form L induction motors, aggregating 845 h.p.

Philadelphia Rapid Transit Co., Philadelphia, Pa.

Four hundred GE-80 motors.

Pressed Steel Car Co., McKees Rocks, Pa.

For Allegheny, Pa.

Two MP 8-200-200-250 volt form L generators.

Rockingham Power Co., Rockingham, N. C.

Three ATB 44-3000-164-4000 volt DS-2 generators, with rheostats.

Three WCT 60-3000-60000/4000 volt transformers.

Two MP 8-3000-400-250 volt exciters.

Switchboard, wire and cables.

One vacuum pump and motor.

One oil tank.

United Railways & Electric Co., Baltimore, Md.

One HC 10-15000-300-575 volt rotary converter.

One I 8-150-375-K-350 volt starting motor.

Three AB 25-550-13200-430 volt transformers.

Cincinnati Office

American Steel & Wire Co., Pittsburg, Pa.

One motor generator set consisting of an ATB 10-540-300-13200 volt, 25 cycle, three-phase generator direct connected to an MP 12-800-300-240 volt motor.

One motor generator exciter set consisting of a CQ 10-(11 kw.-1275)-125 volt generator direct connected to a CQ 10-(18 h.p.-1275)-240 volt motor.

One TC 4-150-750-250 volt, 25 cycle rotary converter.

One HT 25-400-13000-480 volt transformer.

One HT 25-165-13000-170 volt transformer.

Booneville Electric Light & Power Co., Booneville, Ind.

One ATB 12-200-600-2300 volt form P generator with direct connected exciter.

The order for this machine was placed with the General Electric Company without requesting bids from competitive manufacturers. This plant is at present operating General Electric apparatus exclusively and the results obtained are clearly shown by the purchasers' action in the present instance.

Chattanooga Electric Co., Chattanooga, Tenn.

One C 4-75-2400-125 volt Curtis steam turbine-generator to be used as an exciter for a 1000 kw. Curtis steam turbine-generator recently purchased.

8700 lb. T.B. W.P. wire.

Cleveland Electric Illuminating Co., Cleveland, O.

One hundred seventy type H transformers, aggregating 1763 kw.

Thirty-one subway transformers, aggregating 447 1/2 kw.

Five hundred type I meters.

Cleveland, Painsville & Eastern Ry. Co., Cleveland, O.

One TC 6-360-500-600 volt rotary converter.

Columbus Ry. & Light Co., Columbus, O.

Two hundred form 14 D.C. enclosed arc lamps.

(Connersville) Light, Heat & Power Co., Connersville, Ind.

One ATB 4-500-1800-2300 volt two-stage Curtis steam turbine-generator.

One C 2-25-3600-125 volt turbine exciter.

Switchboard.

French Lick Springs Hotel Co., French Lick, Ind.

One 150 kw., 225 rev. per min., 125 volt, engine driven Northern type generator.

T. B. Jones & Co., Memphis, Tenn.

Five three-phase, 60 cycle, 220 volt, form K induction motors, aggregating 190 h.p., for operating grain elevators and other grain lifting machinery.

Jos. Lay Co., Ridgeville, Ind.

One C 2-25-3600-250 volt Curtis steam turbine-generator.

This company which manufactures furniture, especially kitchen cabinets and sideboards, has at present installed General Electric apparatus exclusively and in the purchase of this additional unit did not seek competitive figures.

Nashville Ry. & Light Co., Nashville, Tenn.

Twenty-four three phase, 60 cycle, 220 volt, form K induction motors, aggregating 995 h.p.

Four OC 60-250-2300-230/460 volt transformers.

This apparatus will be installed in the plant of the Wariota Cotton Mills, representing the largest electrically operated cotton mill in the Southern States. This order was secured in the face of extreme competition from all motor manufacturers, and at prices in excess of all other competitors.

New Denison Hotel, Indianapolis, Ind.

One 100 kw., 260 rev. per min., 125 volt, form R generator.

City of Paducah, Paducah, Ky.

Two Cat. No. 12 D Brush arc generators.

Two hundred form 3 luminous arc lamps.

This is the first installation of the luminous arc lighting system in the State of Kentucky and will, no doubt, open a new field for this particular class of apparatus.

Portsmouth Street Ry. & Light Co.,
Portsmouth, O.

One ATB 4-500-1800-2300 volt two-stage Curtis steam turbine-generator.

Four GE-80 partial four-motor equipments.

This company is at present operating two 400 kw. turbines of competitive make which have proved very unsatisfactory, and the installation of the above 500 kw. Curtis turbine unit will give excellent opportunities for a comparative test of the two different types of machines.

Rockville Board of Trustees, Rockville, Ind.

One AS 8-120-900-1150 volt, 60 cycle, single-phase generator, with exciter.

This order was secured at a price higher than that of any other competitor.

Chicago Office

Abingdon Electric Light Co., Abingdon, Ills.

One ATB 12-150-600-1150 volt generator.

American Car & Foundry Co., St. Louis, Mo.

CL-B 220 volt motors, aggregating 360 h.p., for machine tool drive.

Chicago City Ry. Co., Chicago, Ills.

Two 1200 kw. rotary converters.

Five 2000 kw. rotary converters.

Equipment of 9000 volt single-phase air blast step-down transformers, reactive coils and switchboard panels for four sub-stations.

City of La Belle, Mo.

One ATB 8-75-900-2300 volt generator.

Detroit Edison Co., Detroit, Mich.

Two motor-generator sets, each consisting of an MP 14-1000-257-600 volt generator driven by an ATB 28-1060-257-4400 volt motor.

East St. Louis & Suburban Ry. Co.,
East St. Louis, Ills.

One ATB 4-500-1800-2300 volt Curtis steam turbine-generator.

Fort Wayne Electric Works, Fort Wayne, Ind.

For Union Portland Cement Co., Ogden, U.

Fifty-seven induction motors, aggregating 776 h.p.

Hughes & Deiters, Dickinson, N. D.

One ATB 8-100-900-2300 volt generator.

National Railway Construction Co.,
Duluth, Minn.

One ten panel A.C. switchboard.

O. I. Newton's Sons Co., Sparta, Wis.

One ATB 12-200-600-2300 volt generator.

Northwestern States Portland Cement Co.,
Mason City, Ia.

One 150 kw. motor generator set.

Twenty-four induction motors, aggregating 1155 h.p.

Nye, Schneider & Fowler Co., Fremont, Nebr.

For grain elevator, at Omaha, Nebr.

Form K, 60 cycle, 440 volt, induction motors, aggregating 975 h.p.

Southwestern Missouri Electric Ry. Co.,
Webb City, Mo.

Three 250 kw. 30000/11000 volt transformers.

One 30000 volt 750 kw. panel.

Two 11000 volt panels.

Trinity & Brazos Valley Ry. Co., Cleburne, Tex.

Two MP 6-96-225-240 volt form R generator.

Three switchboard panels.

One CI 6-85-750-B-220 volt motor.

Twin City Rapid Transit Co., Minneapolis, Minn.

Twenty-six single end air brake equipments with CP-21 compressors.

United Railways Co. of St. Louis,
St. Louis, Mo.

Fifty form K-28 B controllers.

United States Packing Co., Chicago, Ills.

Two ATB 12-150-600-2300 volt BS-2 complete.

Two CE 4-7 1/2-1450-125 volt BD-2 generators.

One CE 4-7 1/2-850-125 volt DS-2 generator.

Four switchboard panels.

Three H 60-100 kw. transformers.

Two I 14–75–514–440 volt form M induction motors, complete.

60 cycle, form K, induction motors, aggregating 160 h.p.

WESTERN COAL & MINING CO., ST. LOUIS, MO.

One Lidgerwood hoist for lifting 3700 lb., rope speed 400 ft. per min., for the Demming, Ark., mine.

WESTERN GAS & IMPROVEMENT CO., CHICAGO, ILLS.

One ATB 36–750–200–2300 volt water wheel driven generator, with 20 kw. exciter.

Switchboard.

Denver Office

AMERICAN SMELTERS SECURITIES CO.,
NEW YORK, N. Y.

For Arkansas Valley Plant, Leadville, Colo.

One MP 10–400–120–250 volt D.C. generator.

One switchboard.

ANIMAS POWER & WATER CO., ANIMAS, COLO.

Two HT 60–100–15750/15000–460 volt three-phase transformers.

CONSOLIDATED POWER & LIGHTING CO.,
DEADWOOD, S. D.

Three 3 H 60–75–11000/10500 volt transformers.

For Mogul Mines, Pluma, S. D.

Two 100 h.p., two 25 h.p., one 15 h.p., and one 10 h.p. induction motors.

For Golden Reward Consolidated Mining & Milling Co., Deadwood, S. D.

One 200 h.p. form K induction motor, and one 75 h.p. hoist motor.

COPPER QUEEN CONSOLIDATED MINING CO.,
MORENCE, ARIZ.

For Dawson Fuel Co., Dawson, N. Mex.

One switchboard for main generating station.

Four sub-station switchboards.

PORTLAND GOLD MINING CO.,
COLORADO SPRINGS, COLO.

Two 50 h.p., one 20 h.p., two 15 h.p., one 10 h.p., and two 5 h.p. induction motors.

SALT LAKE ELECTRIC SUPPLY CO.,
SALT LAKE CITY, U.

One MP 6–50–305–120/125 volt form R generator.

UTAH FUEL CO., SALT LAKE CITY, U.

One LM 102–B–2–500 volt locomotive.

There have also been sold thirty-eight D.C. motors, aggregating about 182 h.p., and fifty-nine A.C. motors, aggregating 216 h.p.

Small Motor Department

J. D. CLARK WOOLEN CO., WORCESTER, MASS.

Eighteen I 3/4 h.p. loom motors.

BEMENT MILES WORKS OF THE NILES-BEMENT-POND CO., PHILADELPHIA, PA.

Twelve CR 15–230 volt motors, 650/1300 rev. per min., for machine tool drive.

MURPHY POWER CO., DETROIT, MICH.

Eight 230 volt CQ motors, aggregating 135 h.p., for operating ventilating fans.

ELECTRIC MOTOR DRIVEN PUMP FOR FIRE PROTECTION IN LARGE BUILDINGS

By B. E. SEMPLE, Chicago Office

In large cities, where excellent municipal fire departments exist, owners of large buildings carrying heavy insurance are called upon by the insurance companies to provide all possible means of fire protection within the limits of their buildings; such as automatic sprinklers supplied from gravity tanks on the roof, water connections for use by the Fire Department steamers, and connections for the fire-boats when the building is situated near the water front.

To keep the roof tanks filled under normal conditions, and to continue the operation of the automatic sprinklers after the roof tanks become emptied by the breaking out of fire, a large steam pump has usually been installed.

Of late, however, electric motor driven pumping sets, consisting of totally enclosed electric motors direct connected to centrifugal pumps, have begun to replace the steam pump for this purpose, and this arrangement seems to be far superior in every detail. Moreover, in case fire breaks out, the supply of current for operating a motor driven pump, from central station mains through well insulated underground wires, is not so likely to be interrupted by fire or water as is the supply of steam for running a steam pump.

Located just east of the General Electric Company's warehouse in Chicago, on Illinois Street, is one of the largest warehouses in that city, built and owned by the Chicago Dock & Canal Company and leased to the Furniture Exhibition Company. This building, the rear or Chicago River side of which appears in the accompanying illustration, Fig. 1, is of brick, of the latest mill construction, 450 ft. long and 120 ft. deep, and is six stories high, with basement, thus containing 378,000 sq. ft. of floor space. There are four fire walls, dividing the building into five sections. A low pressure boiler supplies steam for heating. The building is supplied with 230 volt direct current from the Chicago Edison Company's system, through underground mains, for operating nine electric freight elevators, and for the electric lighting throughout the building.

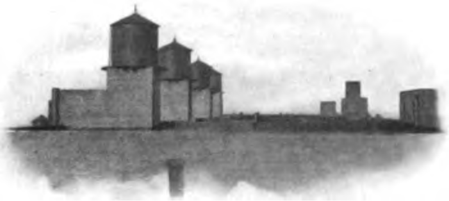


FIG. 1

Gravity Tanks on the Roof of the Chicago Dock & Canal Company's Warehouse, for Operating a Sprinkler System Supplied by the General Electric Motor Driven Centrifugal Pump Shown in Fig. 2

There are 3360 sprinkler heads throughout the building, and a pressure of 150 lbs. per sq. in. is maintained at all times. Four 18,000 gal. gravity tanks are located on the roof, one on the top of each of the four fire walls, as shown in Fig. 1. There are twelve steamer connections and one fire-boat connection.

The sprinkler and roof tank system of the building is supplied by the pumping set shown in Fig. 2, consisting of a CL 6-180-800-Form B-220 volt totally enclosed, submersible motor, direct connected to a spherical, 6 in., four-stage centrifugal pump. This set is in the basement, at about the middle of the building, in a thoroughly fireproof room. The motor is absolutely waterproof, and will continue to run after being entirely submerged; so that if during a fire the floors and walls of the building should collapse and the basement become filled with water no injury would be sustained by either the motor or the pump and the set would not be shut down. The commutator end of the motor casing, at the right, is provided with three hand holes, each fitted with two glass "portholes" through which the operation of the machine may be observed. Air for ventilating the motor is drawn in by a fan on the armature shaft, from outside the building, entering at the opening shown in the commutator end, and exhausting through the back shield at the other end of the machine. The outlet pipe is of special involute form designed to establish a steady current of air through all parts of the motor by setting up a velocity in the exhaust pipe, thereby avoiding eddies or dead

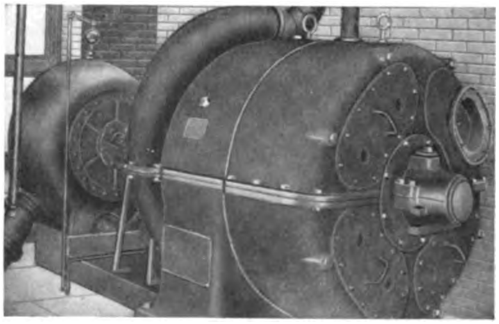


FIG. 2

CL 6-180-800-Form B-220 Volt Totally Enclosed, Submersible Motor Direct Connected to a Centrifugal Pump for Fire Protection of the Chicago Dock & Canal Company's Warehouse

air in any part of the machine. Each bearing is made waterproof by a large plug, threaded into the bearing cap, the removal of which permits inspection of the bearing.

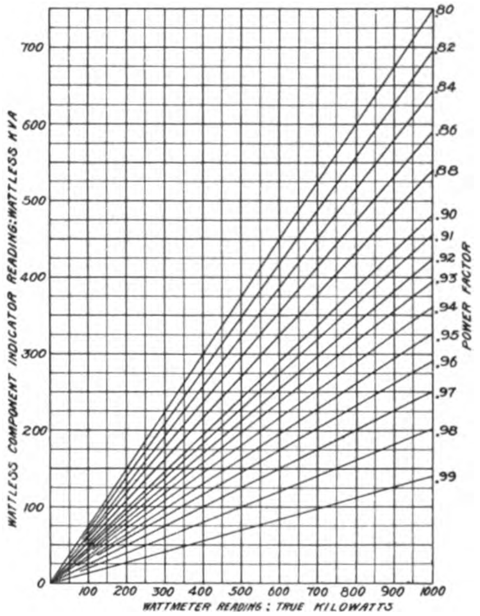
The motor is started and stopped automatically by devices controlled by the pressure in the piping system. The pump has a capacity of 1000 gallons per minute against a pressure of 150 pounds to the square inch when operating at 800 rev. per min. The arrangement of the impellers in the pump is such that artificial means of balancing the end thrust is entirely unnecessary.

The automatic sprinkler system is acknowledged to be one of the very best means for fighting fires, and far more effective than the best work by the Fire Department, inasmuch as the sprinklers throw the water directly on to the fire at its inception. The use of an electric motor driven pump set like the totally enclosed submersible outfit, described above, enormously increases the value and reliability of the sprinkler system, inasmuch as it guarantees that as long as the walls and floors of a building do not collapse water will be delivered to the sprinklers.

POWER FACTOR AND WATTLESS KVA CHART

By J. B. Taylor, Railway Engineering Dept.

The accompanying chart gives a ready means of finding the actual magnitude of the wattless KVA in a given circuit, knowing the reading of a wattmeter and of a power factor indicator; or, conversely, of finding the power factor, from the readings of the wattmeter and of a wattless component indicator. A meter for indicating or recording wattless components consists simply of an ordinary wattmeter with connections so made that there is a phase difference of 90 deg. between the currents in the series and shunt coils of the instrument when the power factor of the load is unity. By suitable connections of a transfer switch in the circuit of the shunt coil, the same instrument may serve both as wattmeter and wattless component indicator. The following



Power Factors and Angles of Lag for Various Ratios of True Watts to Wattless Component

$\left\{ \dfrac{\text{True Watts}}{\text{Wattless Component}} \right\}$	Power Factor	Angle of Lag
∞	1.00	0
7.03	.99	8° 6′
4.93	.98	11° 28′
4.00	.97	14° 4′
3.43	.96	16° 15′
3.04	.95	18° 11′
2.76	.94	19° 56′
2.53	.93	21° 33′
2.35	.92	23° 4′
2.20	.91	24° 29′
2.06	.90	25° 50′
1.85	.88	28° 21′
1.68	.86	30° 41′
1.55	.84	32° 51′
1.43	.82	34° 54′
1.33	.80	36° 52′
1.24	.78	38° 44′
1.17	.76	40° 32′
1.10	.74	42° 16′
1.04	.72	43° 56′
.980	.70	45° 34′
.856	.65	49° 27′
.750	.60	53° 7′
.659	.55	56° 37′
.577	.50	60° 00′

examples will serve to show these uses of the chart:

1. The station is equipped with a wattmeter and a power factor indicator, and it is desired to find the wattless component. The actual wattless KVA may be read direct from the chart. For example, if the wattmeter reads 750, and the power factor indicator reads 0.88, the intersection of the co-ordinate 750 with the diagonal 0.88 shows 405 as the value of the wattless KVA.

2. The equipment consists of a wattmeter and a wattless component indicator, and it is desired to find the power factor in per cent. The power factor may be read directly from the chart. For example, if the wattmeter reads 500 and the wattless component indicator reads 300, the intersection of the co-ordinates 500 and 300 shows a power factor of 86 per cent.

As a matter of convenience, a table is appended showing angles of lag and power factors corresponding to various ratios of true watts to wattless component.

GUTHMAN STEAM LAUNDRY, ATLANTA, GEORGIA

An Example of a Modern Establishment in Which Electricity Plays an Important Part

By M. E. Bonyun, Atlanta Office

Within the last few years the laundries of the country, especially in the larger cities, have undergone great improvements. In organization, sanitary conditions and care for attractive surroundings, even to the appearance of the delivery wagons, the steam laundry of to-day presents a marked contrast to the forbidding and dubious quarters and indifferent business methods often in vogue up to a recent date. Perhaps the most important agency in this reform has been the application of electricity to laundry work: for lighting and power, and latterly, with the introduction of the electric flat iron, for heating. The modern electrically equipped laundry, with its abundant lighting, deft and sanitary manipulations, and inviting surroundings, welcomes inspection by the public and inevitably commands patronage.

Such a model laundry, rivaling in equipment any similar establishments in the larger Northern cities, has recently been started in the City of Atlanta. It is the purpose of this article to describe the electrical equipment of this plant, which has been visited by a number of practical laundry men and has already become a pattern for laundries in Charleston, S. C., and Mobile, Ala.

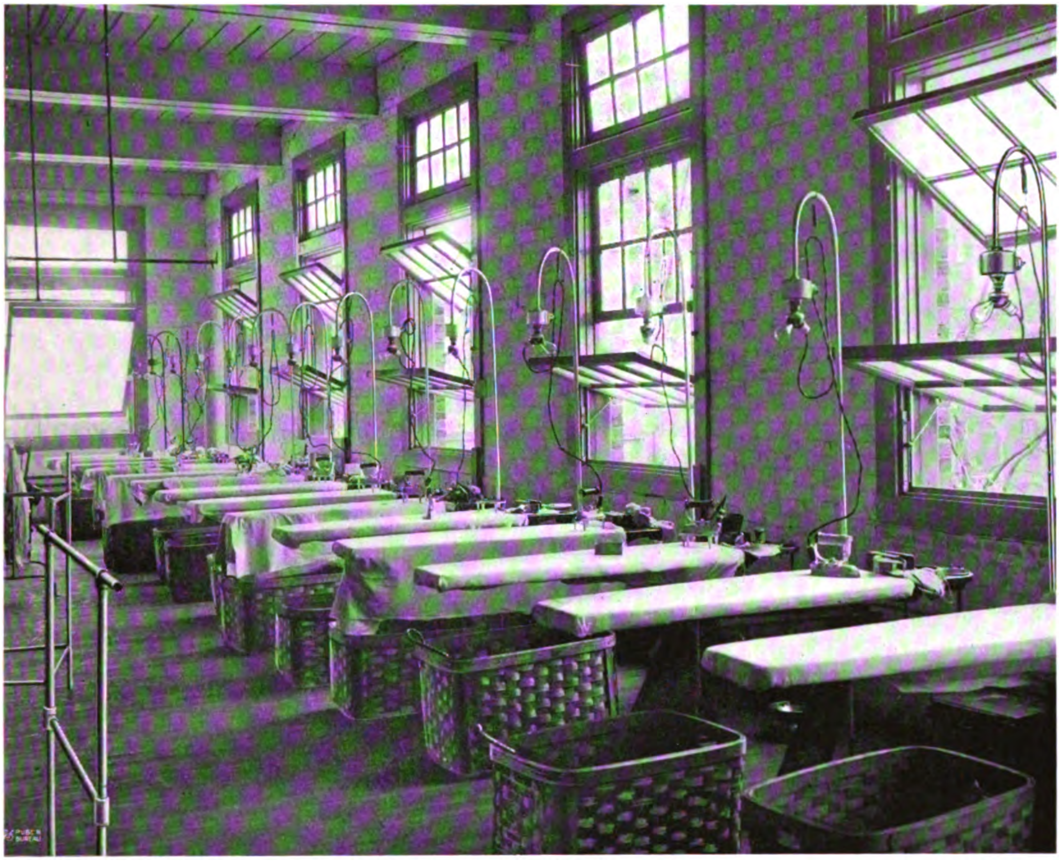
The Guthman Steam Laundry is thoroughly self-contained, having its own steam and electric plant. The building is a substantial brick structure of three floors and a basement, comprising about 24,000 sq. ft. of floor space.

In the basement there are installed a battery of two water tube boilers of 200 h.p. capacity. These boilers supply steam at comparatively low pressure for laundry purposes, as well as steam at about 100 lbs. pressure for an automatic engine which is belted to a 55 kw., compound wound, 110 volt D.C. generator for supplying the laundry with light and power. The basement also contains a machine repair shop, storeroom and lockers for employees.

On the first floor are the neatly fitted up executive offices of the laundry, arranged to handle the business end of the establishment under modern time saving methods.

On this floor also are installed four mangles. These machines, as the initiated know, are used for ironing large pieces of domestic linen, such as sheets, tablecloths, etc. Each mangle is driven by its own individual electric motor of 5 h.p. capacity, direct connected, so that no shafting is required.

The second floor contains four large steam "dry houses," each provided with a motor driven fan for circulating the hot air. There are also installed shirt bosom ironers, body ironers, wristband ironers, collar ironing apparatus, moisture applying machines, and starching apparatus, each separate piece of machinery being driven by an individual motor. On this floor also is the hand ironing department, equipped throughout with electric flat irons.



View in the Hand Ironing Room of the Guthman Steam Laundry, Atlanta, Georgia

In this room there are forty 6-lb. and 3-lb. General Electric Flat Irons. Each ironing table is equipped with a special gooseneck fixture fitted with an indicating lamp socket and a flat iron receptacle

The third or top floor is of cement, 14 in. thick. Here are located the primary washing machines, and the centrifugals for extracting the water from the material. There are fourteen primary washers, each having its special steam and hot and cold water connection. The apparatus on this floor is driven by two lines of shafting, each belted to a 15 h.p. motor, group drive for this apparatus having been found advisable from an engineering standpoint.

Since all the primary washing and sorting is done on the top floor—a process usually conducted in the basement of ordinary laundries—with abundant forced ventilation through the ceiling, the odors necessarily associated with the steaming hot clothes and soapsuds are at once expelled and do not in the least permeate the building.

An electric elevator carries the laundry work directly from the arriving delivery wagons, in the rear of the building, to the sorting room on the top floor. After the primary washing on this floor the work descends, through the various processes, to the first floor, where it is checked and billed and turned over to the outgoing delivery wagons.

Perhaps of all of the electrical equipment that this laundry possesses, that which appeals most to the interested visitor is the hand ironing department.

The modern laundry, like all other modern industries, depends on hand labor as little as possible. Machinery, automatic or non-automatic, is applied wherever its use will economize time or achieve improved results. The accomplishment of these ends is sought as carefully in the modern steam laundry as in the case of any other commercial industry. There is, however, a class of delicate ironing work—such as laces, embroidered "waists," bodices, and complete dresses of delicate material or elaborate design, together with all garments made of silk, plain or trimmed—which must be ironed by hand.

In the Guthman Laundry, there are installed thirty 6 lb. and ten 3 lb. electric flat irons of General Electric manufacture, superseding a similar number of cumbersome and inefficient gas heated irons used in the old laundry. Over each ironing table is installed a special fixture, goosenecked at the top and fitted with a receptacle for the connecting plug of the flat iron and with a socket for a 4 c-p. indicating lamp, both controlled by a 10 amp. snap switch. This novel indicating lamp arrangement assists the foreman of this floor to supervise the work, by enabling him to see at a glance just what irons are doing useful work, or whether any irons are standing idle with current turned on. The arrangement has been found to be practical and satisfactory.

The truest verdict of the successful operation of a device is to be obtained from its commercial user. The writer asked several of the flat iron operatives, independently, their opinions of the electric irons as compared with the gas heated irons, and the invariable reply was vastly in favor of the electric iron.

The gas heated iron is always hard to keep at just the right heat. Frequently the operatives have to stop work to allow the irons to heat up to the proper working temperature; and on the other hand the irons easily become so overheated, by being left over the gas, as to scorch the work. In using gas heated irons, the operators, therefore, not only have to waste part of their time in waiting for hot irons, but have to keep at hand a tub of cool water in which to chill the iron when it becomes too hot, so that the ironing work in a laundry where gas heated irons are used is decidedly unsteady. In this respect the electric iron is at a distinct advantage. When the iron is in use on light work, or occasional work, it is so easily turned off by the switch (to be turned on again later, if necessary) that it never becomes overheated; and once brought to the right temperature is easily kept there, the heat constantly flowing to the work as required.

It has been demonstrated beyond a doubt at the Guthman Laundry, that with the use of electric irons 30 per cent more work can be done by each operative per working day.

Many of the original ideas which have been carried out in this laundry were advanced by Mr. George Wade, who was formerly connected with the General Electric Company, and who was employed as consulting engineer for this proposition.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

Tungsten Incandescent Lamps

[Elec. Wld., Aug. 18, 1906, p. 319]

A brief note stating that high candle power Tungsten lamps, having a consumption of between 1 and 1 1-4 watts per candle and having a life equal to the present carbon filament lamps, are about to be put into production by the General Electric Company.

New Electrical Installations on the Continent

[Elec. Rev., Aug. 25, 1906, p. 288]

HELLENIC ELECTRIC COMPANY AND ATHENS-PIRAEUS RAILROAD ELECTRIFICATION

An account of the plant erected to supply Athens, Greece, and the surrounding country with alternating current, and three electric railways with direct current. When complete, the main generating station is to contain six main generating sets of 750 kw. each. Three of these sets will supply 5500 volt alternating current, two will supply 600 volt direct current, and the sixth set, consisting of a 1000 h.p. engine coupled to a D.C. and an A.C. generator, will be held as a reserve for either service. Two overhead lines run to Athens and two more to the Piraeus and Phaleron. All of the electrical equipment of the generating station and of the railroad is being built by the Mediterranean Thomson-Houston Company. The article is illustrated by a map, and describes the equipment of the sub-station and rolling stock.

Hauling of Freight, and Other Operating Features of the Interurban Railway Company, Des Moines, Ia.

[St. Ry. Jour., July 28, 1906, p. 138]

This road has taken up the hauling of freight in a very business-like way, with an equipment consisting of one steam and two electric locomotives, seventy coal cars, and twelve box cars, and handles all of the freight for several coal mines, tile works and brick yards, as well as most of the stock and produce of the farmers along the route. The larger electric locomotive, illustrations of which are given, was built in the shops of the Des Moines City Railway Co., and is equipped with four GE-73 motors and Sprague-General Electric type M control. The special methods of soliciting and handling business, employed by this road, are interestingly described.

The Present Status of the Electrification of the New York Zone of the New York Central & Hudson River Railroad

(Elec. Rev., Sept. 8, 1906, p. 354)

An article by W. J. Wilgus describing certain modifications of the original plans for electrifying this zone. Because of the difficulty in abolishing grade crossings, it has been found necessary to limit the electrical zone for the present to stretches of about seven and thirteen miles, on the Hudson and Harlem divisions, respectively, out of the ultimate twenty-five and thirty miles. In order to avoid congestion in the handling of the enormous traffic it will be necessary to make the change from steam to electricity gradually. Illustrations are given of the outside construction work, and of the Port Morris and Yonkers generating stations and the Mott Haven sub-station, showing the installation of General Electric apparatus including four Curtis steam turbine-generators.

The Commerce Street Power Plant of the Milwaukee Electric Railway and Light Company

[Elec. Ry. Rev., July, 1906, p. 384]

A complete account of the recent enlargement of this plant, which is now equipped to furnish 13,200 volt, 25 cycle, three-phase, A.C., 4000-2300 volt, 60 cycle, four-wire, three-phase, A.C., and 600 volt D.C. services. The main floor of the station is divided into boiler and engine rooms, above which are the coal bunkers and machine shop. The engine room equipment consists of four vertical cross-compound engines, each direct connected to a 1500 kw., 13,200 volt, 25 cycle, three-phase, revolving field General Electric generator excited by small non-condensing Curtis steam turbine-generators, and of four similar engines driving 2000 kw., 600 volt General Electric railway generators. There are also two 1000 kw., 60 cycle, 4000-2300 volt four-stage Curtis steam turbine-generators, each equipped with a 150 kw. motor driven exciter. Details of the steam plant and gravity oiling system are fully described and illustrated.

Omaha Electric Light and Power

[Public Service, Sept., 1906, p. 8]

An article describing the plant of the Omaha Electric Light and Power Co. which supplies the City of Omaha and vicinity with current. A good part of the article is devoted to the financial history of the company. Great expenditures have been made to replace out-of-date apparatus. The present equipment, which is briefly described, and illustrated by a general view of the interior of the generating station, comprises apparatus aggregating 4050 kw. capacity, which will shortly be increased to 5700 kw. by the addition of a new Curtis steam turbine-generator.

Nichtheroy Power Transmission

[Elec. Wld., Aug. 18, 1906, p. 322]

A brief note describing the 44,000 volt transmission scheme which supplies hydro-electric generated power over steel tower lines to three cities, including Nichtheroy situated about thirty miles north of Rio de Janeiro. The generating station equipment includes three three-phase, revolving field, 2000 kw., 2300 volt generators with 75 kw., 220 volt exciters, a 3000 kw. generator as a reserve, and a bank of six 1000 kw. transformers.

General Electric Company Review, September, 1906

INDEX

NOTE: In order to save space, the larger number of items reporting sales to Central Station, Traction and Transmission Companies, containing matter of transient interest only, will not be indexed, but may readily be located by looking through the "Recent Important Sales" columns of the REVIEW.

- Abstracts of Important Technical Articles 91
- Automobile Manufacturers:
  - Electric Vehicle Co., Hartford, Conn. 82
- Car Builders:
  - American Car Foundry Co., St. Louis, Mo. 84
  - Pressed Steel Car Co., McKees Rocks and Allegheny, Pa. 83
- Cement Manufacturers:
  - Nazareth Portland Cement Co., Nazareth, Pa. 83
  - Northwestern States Portland Cement Co., Mason City, Ia. 84
  - Union Portland Cement Co., Ogden, U. (under "Fort Wayne Electric Works, Fort Wayne, Ind.") 84
  - Northwestern State Cement Co., Mason City, Ia. 84
- Central Station Companies (see "Generating Systems").
- Chart, Power Factor (see "Power Factor")
- Coal Companies:
  - Carbon Coal Co., Langdondale, Pa. 82
  - Fairmont Coal Co., Fairmont, W. Va. 83
  - Western Coal & Mining Co., Demming, Ark. 85
- Colleries:
  - Hyde Park Mine, Scranton, Pa. 82
  - Pyne Mines, Taylor, Pa. 82
  - Woodward Colliery, Kingston, Pa. 82
  - (See also D., L. & W. R. R. Co., under "Traction")
- Construction Companies:
  - National Railway Construction Co., Duluth, Minn. 84
  - (See also "Engineers and Contractors")
- Electrical Supply Companies:
  - Salt Lake Electric Supply Co., Salt Lake City, U. 85
- Engineers and Contractors:
  - Hanley-Casey Co., Chicago, Ills. 83
  - New England Engineering Co., Waterbury, Conn. 83
  - Nye, Schneider & Fowler Co., Fremont, Nebr. 84
  - Robinson, Andrew J., New York, N. Y. 82
  - Traction Engineering Co., Olean, N. Y. 82
  - (See also "Construction Companies")
- Fans, Ventilating:
  - Murphy Power Co., Detroit, Mich. 85
- Furniture Manufacturer:
  - Lay Co., Joseph, Ridgeville, Ind. 84
- Generating Systems:
  - Hellenic Electric Co., Athens, Greece 91
  - Mexican Electric Light & Power Co., Necaxa and Mexico City, Mexico 80
  - Milwaukee Electric Railway & Light Co., The Commerce Street Power Plant of the 91
  - Omaha Electric Light & Power Co., Omaha, Nebr. 91
  - (See also "Isolated Plants," "Traction" and "Transmission")
- Grain Elevators:
  - Jones & Co., T. B., Memphis, Tenn. 83
  - Lay Co., Joseph, Ridgeville, Ind. 84
  - Nye, Schneider & Fowler Co., Fremont, Nebr. 84
- Heating Devices, Electric:
  - Laundry, Guthman Steam, Atlanta, Georgia (Electric Flat Irons), by M. E. Bonyun 88
- Isolated Plants:
  - Mayfair Apartment House, New York, N. Y. 82
  - Municipal Building, Washington, D. C. 83
  - New York Club, New York, N. Y. 82
  - New Denison Hotel, Indianapolis, Ind. 84
  - French Lick Springs Hotel Co., French Lick, Ind. 83
- Lamp, Luminous Arc:
  - Multiple D.C. Luminous Arc Lamp, by G. N. Chamberlin 75
  - (See also "Municipal Plants")
- Lamps, Tungsten Incandescent 91
- Laundry, Guthman Steam (See "Heating Devices, Electric")
- Mills:
  - Cotton Mills, Wariota, Nashville, Tenn. (under "Nashville Ry. & Light Co.") 84
  - Paper Co., International, New York, N. Y. 82
  - Woolen Co., J. D. Clark, Worcester, Mass. 85
  - Powder Co., Laflin & Rand, Oriental Siding, Fairchance, Pa. 83
  - Powder Mills: Du Pont, E. I., Wilmington, Del. 83
- Mining and Smelting Companies:
  - American Smelters Securities Co. (Arkansas Valley Plant), Leadville, Colo. 85
  - Barnes & Tucker Co., Barnesboro, Pa., (Apparatus for Lighting) 82
  - Copper Queen Consolidated Mining Co., Morence, Ariz. 85
  - Golden Reward Consolidated Mining & Milling Co., Deadwood, S. D. (under "Consolidated Power & Lighting Co., Deadwood, S. D.") 85
  - Iowa Gold Mining & Milling Co., Silverton, Colo.
  - Mogul Mines, Pluma, S. D. (under "Consolidated Power & Lighting Co., Deadwood, S. D.") 85
  - Portland Gold Mining Co., Colorado Springs, Colo. 85
- Miscellaneous:
  - Brewery, Salt Lake, Salt Lake City, U.
  - Chicago Dock & Canal Co., Chicago, Ills. 86
  - Fuel Co., Dawson, N. Mex. 85
  - Fuel Co., Utah, Salt Lake City, U. 85
  - Furniture Exhibition Co., Chicago, Ills. 86
  - Plate Glass Co., American, Kane, Pa. 82
  - Steel & Wire Co., American, Pittsburg, Pa. 83
- Motor Drive:
  - Bement Miles Works of the Niles-Bemont-Pond Co., Philadelphia, Pa. 85
  - Buffalo Forge Co., Buffalo, N. Y. 81
  - (See also particular applications and "Miscellaneous")
- Municipal Plants:
  - La Belle, Mo. 84
  - Paducah, Ky. 84
  - Rockville, Ind. 84
- Packers:
  - United States Packing Co., Chicago, Ills. 84
- Powder Mill (see "Mills")
- Power Factor and Wattless KVA Chart, by J. B. Taylor 87
- Pump, Electric Motor Driven, for Fire Protection in Large Buildings, by B. E. Semple 85
- Recent Important Sales 81
- Smelters (see "Mining and Smelting Companies")
- Switches, Oil Break, Remote Control, by H. L. Smith 78
- Traction:
  - Athens-Piraeus Railroad, Athens, Greece 91
  - Delaware, Lackawanna & Western R. R. Co., Holden Colliery, Kingston, Nanticoke, National Colliery and Scranton, Pa. 81, 82
  - Delaware, Lackawanna & Western R. R. Co., Scranton, Pa., (Mining Locomotives) 82
  - Des Moines City Ry. Co., Des Moines, Ia. 91
  - Electrification (See "New York Central")
  - (European) Installations, New Electrical, on the Continent 91
  - Hellenic Electric Co., Athens, Greece 91
  - Freight Hauling (See "Interurban Ry. Co., Des Moines, Ia.")
  - Interurban Ry. Co., Des Moines, Ia., Hauling of Freight, and other Operating Features of the 91
  - Milwaukee Electric Ry. & Light Co., Milwaukee, Wis. 91
  - Mediterranean Thompson-Houston Co., Athens, Greece. 91
  - New York Central & Hudson River Railroad, The Present Status of the Electrification of the New York Zone of the 91
- Transmission:
  - Necaxa Transmission, Mexican Electric Light & Power Co., The 73
  - Nichtheroy Power Transmission 91
- Wattless KVA (See "Power Factor")

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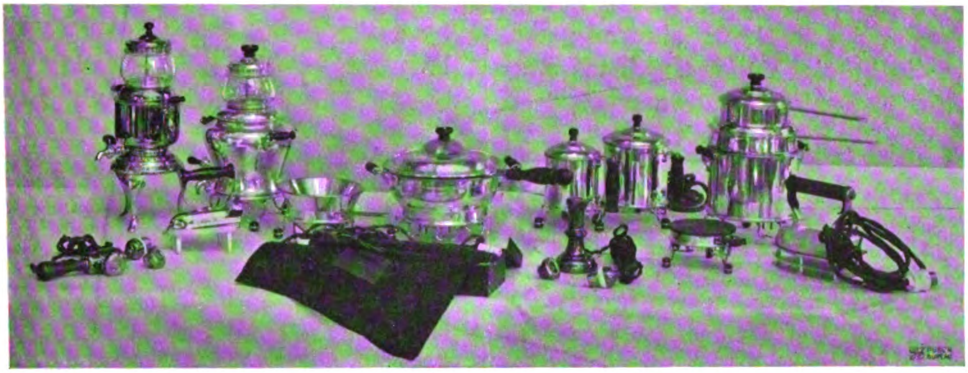
GENERAL ELECTRIC COMPANY REVIEW

Vol. VII SCHENECTADY, N. Y., OCTOBER, 1906 No. 6

SOME REASONS FOR THE SUCCESS OF THE NEW ELECTRIC HEATING DEVICES IN THE HOME

By H. W. HILLMAN

During the past year a great deal has been said and written in regard to the use of electricity in the home. In view of the recent remarkable improvements in electrical appliances, especially heating devices, the electrical papers for a long time past have taken an unusual interest in this subject so immediately connected with the industry. More significant still, a large number of newspapers and popular magazines, desiring to inform their readers on such a prominent subject, have published articles fully illustrating the many electrical appliances for producing light, heat and power in the household.



Group of General Electric Heating Devices that may be used on the Lighting Circuit

Coffee Percolators, Cigar Lighters, Chafing Dish, Heating Pad, Frying Pan, Toaster, Flat Irons, Pint Water Heater (which may be used as a Baby Milk Warmer), Quart Water Heater (which may be used as a Baby Milk Warmer, Cereal Cooker, etc.), and Two Quart Combination Cereal Cooker

The fact that the press at large has so earnestly taken up the matter indicates a widespread popular interest, the cause of which it may not be amiss to set forth briefly.

The writer's experience with electrical devices in his home during the past three years has led to serious consideration of the reasons why the people in general regard electrical appliances so favorably. A household device might be especially convenient and yet fail to attract the attention of the housewife due to the high initial cost; or it might possess both the essential features of convenience and low initial cost yet would never attain general popularity for household use, on account of a high operating cost.

It is believed that the prime reason for the great present popularity of household electrical appliances is to be found in the excellent engineering design which has been exhibited in these appliances, particularly during the past two years.

A competent electrical engineer will consider all phases of a subject before submitting a design of an article to be commercially introduced. Such considerations have been applied in the design of the type of electrical appliances used in the writer's home; and the problem was solved by reducing the initial cost of the appliances until they compared favorably with the ordinary stove-heated utensils, and by securing a reasonable operating cost at the average rates of charge by central station companies throughout the country.

A few remarks in illustration of these two points—low initial cost and low operating cost—may be interesting and instructive.

In regard to initial cost of the new devices, the engineers have shown great ingenuity in their designs. The egg steamer, for example, is known as a five-combination dish, and is equivalent to five utensils inasmuch as it performs as many different operations, adapted to the daily routine of the household. The "multiple value" of this utensil is not a matter of theory alone: its use as a water heater, egg steamer, cereal cooker, potato steamer, and baby food warmer, in rotation, is being demonstrated every day. The device serves the different purposes mentioned equally well and yet its initial cost is only slightly higher than it would be as a water heater, or any other device. The illustration shows several of the different uses of this utensil, which is simply an example of many combination dishes designed to give economy in first cost.

Referring now to the important matter of operating cost: the use of electric cooking devices has introduced a number of time- and labor-saving methods, that tend also to economy of current. For example, it is a matter of common knowledge that either on the lid of the coal stove or over a gas flame, for boiling eggs, a considerable quantity of water (say a pint) is ordinarily used. Several minutes are required to bring the water to a boil, and then the eggs are placed in the dish for 3, 3 1/2 or 4 minutes, according to whether a soft, medium or hard boiled egg, respectively, is desired. In using the electric egg steamer, on the other hand, a tablespoonful of water placed in this utensil comes to a boil in 45 seconds after the current is turned on; so that if the eggs are put into the utensil at this point, and the cover put on, the eggs will be *steamed* soft, medium or hard, as the case may be, in less than one-half the time that has commonly been required for *boiling* eggs in the old way.

The writer claims that this scheme of saving both time and current, suggested by a thoughtful engineer, has been singularly advantageous in demonstrating the practical success of electric heating devices in the home. The same scheme is utilized in cooking potatoes and cereals; and in heating baby's food, where time is a very important factor, and where the expense is also seen to be a factor when it is considered that baby's food may be required six or seven times a day, or more than two thousand times a year.

This instance of economy in time and expense is dwelt upon simply as an illustration of the saving which is to be effected by using many of the new devices, and which brings their cost of operation down to such a trifle that the people will use them extensively. Testimony in the same direction is the fact that the writer's monthly bills for current, covering a period of two years at the rate of 5c per kw-hr., have been very low. During the past year, a great many homes have been similarly fitted up with the improved devices; and under the same conditions, with the same price of current, the bills have checked.

Convenience is just as truly a form of economy as a saving of dollars and cents, or of hours and minutes, and its value is especially well recognized by the busy American public. Even supposing that ordinary stove-heated utensils might be made so as to utilize in them, also, the scheme of cooking by steam instead of by boiling water, there are many household operations that can be performed by electricity at a cost so slight that a little further economy, obtainable by using fuel, does not compensate for the convenience which the electrical appliances possess compared with any fuel-heated appliances. The engineer who originated the economical method of cooking by electricity, above described, has by such methods brought the cost of operating electric heating devices down to a point well within the means of nearly all classes. In other words, electric heating devices have been made serious competitors of old-fashioned methods by completely changing the conditions under which these devices operate, as compared with what these conditions were a few years ago.

At this point the question may be asked: If only a tablespoonful of water is used, what happens if the device is inadvertently left with the current turned on, with all of the water evaporated? The engineer above referred to also found a way to make the devices indestructible, i. e., a construction so sturdy that neither the dish itself nor the heating element will be injured if the current is left on indefinitely with the liquid all boiled away; whereas the ordinary cooking utensil is quickly ruined if left, dry, over an oil or gas flame, or on a coal stove.[*] The new electric heating devices are actually more rugged than the ordinary stove-heated pots and pans, which will have to be improved themselves if they are to compete, in "life" under practical household conditions, with the new electric utensils!

As a user of electric household utensils exclusively, the writer is convinced that the above facts are of far reaching importance as indicating practical efficiency, and that as these facts become known more and more widely among households the people in general will come around to the same views.

The entire line of General Electric heating devices exemplifies the two advantages, already mentioned: economy in first cost, and economy in operation. These advantages, taken in conjunction with the favorable rates for current for electric heating purposes which have been commonly established by most of the Central Station companies, have been strong factors in popularizing the entire line of electric household appliances.

TYPE UY MOTOR CONTROLLING PANELS

By W. C. YATES

The type UY motor controlling panel is a combination of all the devices necessary to insure proper control of variable speed motors. The accompanying illustrations, Figs. 1, 2 and 3, are views of two panels of this type.

The type UY panel comprises double pole circuit breaker, enclosed fuses, starting switch and no-voltage release, field controlling switch, and suitable terminals—all mounted on a slate slab, with the resistance behind the slab. The circuit breaker and fuses are of the standard type. The starting switch is provided with an auxiliary break at the first live point, which for currents below 100 amp. consists of a quick break finger, and for larger currents takes the form of a magnetic blowout. All current carrying parts are renewable from the face of the panel, and the sliding contact is protected by a carbon block.

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[*] This fact becomes clear when it is borne in mind that the heating unit of a modern General Electric utensil is designed to prevent excessive heating of the dish; whereas the heat of a stove of any kind on which an ordinary utensil may inadvertently be left is sufficient to destroy the utensil in a very short time.

For normal full load motor currents above 50 amp. the starting arm is short-circuited in the running position.

The parts of the field controlling switch are easily renewable from the front of the panel. This switch is so interlocked with the starting arm as to prevent the closing of the armature circuit when the motor field is weakened.

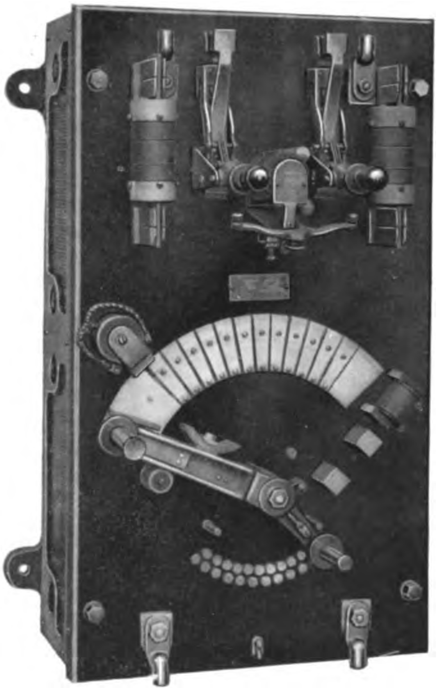


FIG. 1
Type UY Panel for Starting and Regulating a 4 H.P., 220 Volt Motor

The starting resistance is of either the iron grid or enclosed card type, depending upon the size of the motor. The field regulating resistance is of the enclosed card type. The resistances are entirely enclosed at the top, bottom and rear, and are ventilated by screens at the sides.

SALES OF MERCURY ARC RECTIFIERS

The sales of the mercury arc rectifier during its first year have been unprecedented and the present outlook is that more than double the business will be handled this year.

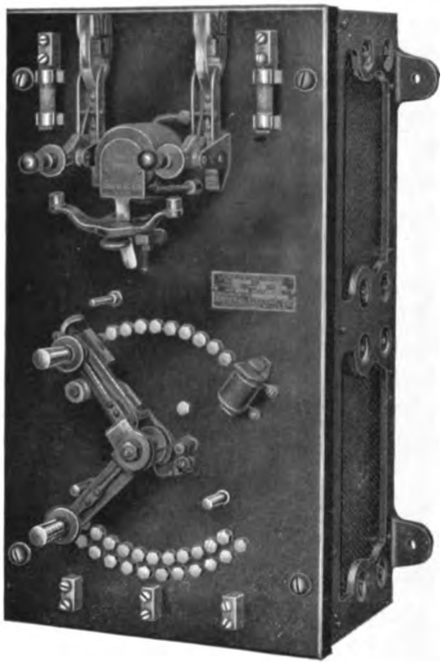


FIG. 2
Type UY 60 H.P. Combined Starter and Regulator Panel

Multiple Rectifier Outfits

Nearly 1200 low tension rectifier outfits, for operation on 110, 220 and 330 volts A.C., have been sold. About 60 per cent of these outfits were of 30 amp. capacity, the balance being of 40, 20 and 10 amp. capacity. Perhaps 90 per cent of these outfits were sold for charging the storage batteries of telephone exchanges and electric automobiles, and the balance for operating searchlights, for operating stereopticon lamps and for supplying small D.C. motors where it was desired to make use of the speed variation and characteristics of the D.C. motor but where A.C. current only was available. As an example of this use, one mercury arc rectifier outfit was sold to supply two 220 volt 1 h.p. motors at the plant of the Mexican Development Co., operating at 440 volts A.C.

A number of 5 amp. outfits for charging the ignition storage cells for gasoline automobiles were also sold. The panel of one of these outfits is shown in the accompanying illustration. The acknowledged superiority of storage cells for ignition purposes in automobile work promises to open a large field for mercury arc rectifiers for this purpose, inasmuch as direct current is rarely available except in the large cities, and even where it is available the charging of the storage batteries of from two to six cells by the use of resistance in series is highly uneconomical.

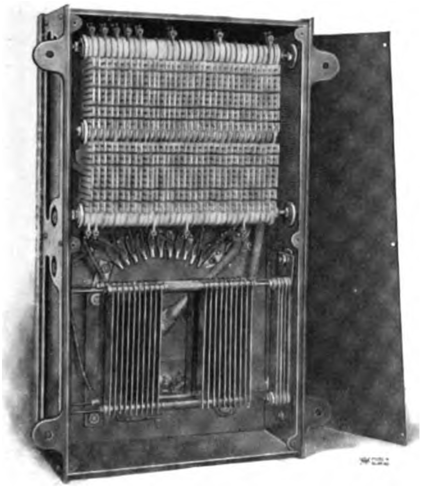
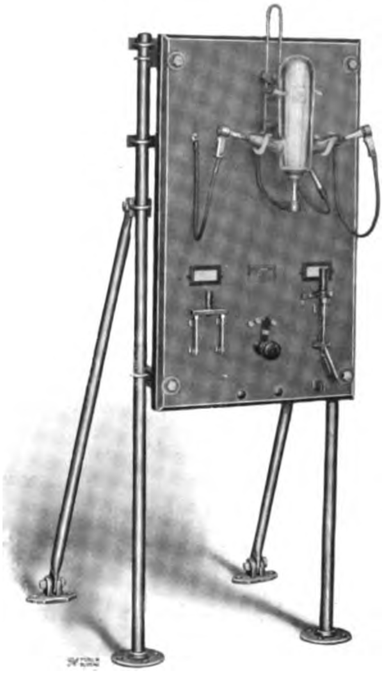


FIG. 3
Rear View of Type UY 60 H.P. Combined Starter and Regulator Panel

In this connection a line of mercury arc rectifier switchboards, for installation in garages, is about ready. These switchboards consist of two panels, one for the mercury arc rectifier and its equipment and the other equipped with charging connections for charging the batteries of six vehicles at a time, on a series multiple arrangement. This apparatus gives the most efficient charging apparatus ever devised, inasmuch as the mercury arc rectifier is capable of far greater voltage variation with good efficiency than the motor generator set. Where a single motor generator set is used with an individual rheostat in each charging circuit, hundreds of dollars worth of energy is wasted every year in dead resistance entirely apart from the inherent lack of economy in small motor generator sets as compared with the mercury arc rectifier.



Mercury Arc Rectifier Panel for Charging Ignition Batteries

Series Rectifier System for Arc Lighting

Since the Series Rectifier System was first introduced orders have been received for over 90 sets with a total capacity of 5000 luminous arc lamps; the largest installation being at Portland, Oregon, where a system of 1200 lights capacity has been installed.

One of the most important advantages of this system is the readiness with which it can be adapted to circuits of any frequency from 25 to 140 cycles. The standard sets are designed for 60 cycles, but outfits have been designed for and are in operation on circuits of 25, 33, and 40 cycles.

For further information the reader is referred to a paper entitled "The Series Luminous Arc Rectifier System," read by Mr. N. R. Birge before the Ohio Electric Light Association, August 23, 1906.

AGGREGATE PERIPHERAL VELOCITIES IN STEAM TURBINES OF DISSIMILAR TYPES

By J. G. CALLAN, Engineering Dept.

Some corollaries derivable from the principles of turbine design set forth in Dr. Steinmetz's article in the June "Review" may not be devoid of interest.

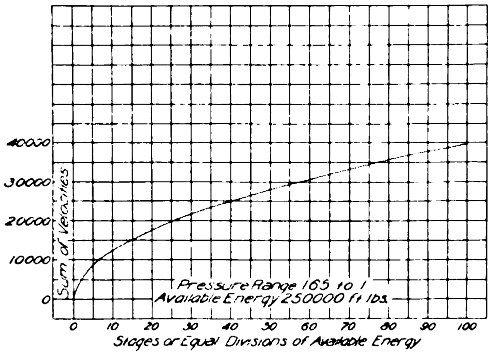
Comparing turbines of different types, designed to give best efficiency for the same pressure range, let us consider in each case the summation of peripheral speeds of all revolving wheels. A large apparent disparity will be found. For instance, a certain Parsons turbine shows this summation of all its wheel velocities to be about 15,000 ft., a Curtis for similar conditions and performance about 3000 ft., and a De Laval (single-wheel) about 1000 ft. Why this divergence? For convenience we may compare the first mentioned and last mentioned turbines, in turn, with the Curtis, which occupies a mid-position. A small part of the disparity is in each case due to incidental causes. The semi-reaction Parsons type element, other things being equal, must have a speed about 40 per cent above that of a pure impulse wheel to enable it to extract the same energy from a steam stream; and the De Laval wheel, but for difficulty in obtaining material to endure it, might with advantage be run at a somewhat higher speed than is commercially used. These considerations account, however, for but a small part of the high relative aggregate speed of the former and the low speed of the latter. The reason, for the main part, is inherent in the laws of fluid flow, as we shall see by a moment's analysis.

If a stream of water falls say a thousand feet, it might obviously drop the entire distance in one leap or it might form a cascade of a hundred ten-foot falls, ten one-hundred-foot falls, a thousand falls a foot high, and so on. In the case of the single drop the theoretic terminal velocity is about 253 feet per second; in the cascade with a thousand one-foot falls the theoretic velocity at the end of each is about 8 feet per second, the sum of all the terminal velocities being 8000 feet. These results follow directly from the formula $V = \sqrt{2gh}$, and are rationally explained by the consideration that the energy of the moving water varies as the square of its velocity; whence it would be the sum of the squares, not of the first powers, of the terminal velocities that would remain constant whatever the number of the falls in the cascade.

Precisely similarly with the spouting velocity of steam. The theoretic velocity of steam issuing from 150 lb. boiler pressure directly into vacuum is a certain amount—about 4000 feet per second. If the steam issues from the boiler to a chamber of somewhat lower pressure, thence to one slightly lower still, thus expanding to vacuum by a series of N equal steps, each spouting velocity is not $\frac{V}{N}$, but $\frac{V}{\sqrt{N}}$, and the aggregate of the N equal velocities $\frac{NV}{\sqrt{N}}$, or $\sqrt{N}$ times V. So if we plot a curve having as abscissae the number of equal stages, N, through which steam is expanded from one fixed pressure to another, and as ordinates a summation of the N resulting spouting velocities, we shall have a parabola. Such a curve is shown herewith.

Now, since the correct pheripheral velocity of a bucket wheel is a direct first power function of the spouting velocity of the steam driving the wheel, the reason for the high summational peripheral velocity of turbines of many stages as compared with those of few becomes apparent in the high summational spouting velocity.

Considering impulse turbines having equal energy per stage and working between fixed pressure limits, an interesting further corollary is the fact that, neglecting bucket angle cosines and correction factors, this summational or aggregate peripheral speed is affected only by the number of stages and not by the number of wheels per stage. One wheel in a stage at high velocity, two in the stage at half that velocity or three at a third that velocity all have the same power of extracting and appropriating energy from the steam jet, and obviously each of these constructions gives the same contribution to the total summational velocity.



Curve showing relation between the number of stages through which steam is expanded and the summation of the spouting velocities in feet per second

Further, neglecting correction factors and losses, and referring to the wheel velocity in one stage as the "stage velocity," the sum of the squares of all the stage velocities should always be the same. Also, it is clear that with turbines of a given type using as means of reducing shaft velocity both a number of stages, and plurality of wheels per stage, neither the sum of the first nor second powers of the wheel velocities will be a constant.

These considerations may appear more curious than practically valuable, but in a broad comparison of types and of general policies in design, they are not without usefulness and suggestiveness. Thus, for turbines of equal shaft speeds the ratio of total numbers of buckets required would be the ratio of summational peripheral speeds multiplied by the bucket pitch ratio. Considering again, by way of example, current good practice in Parsons design compared with that for Curtis design, we find that the small pitch Parsons buckets, which are rendered expedient by considerations of length, taken in conjunction with the high aggregate peripheral velocity factor, account at once for the very large number of buckets used in Parsons designs, and show that the surprisingly wide divergence from Curtis practice is not incidental or chargeable to different traditions of design, but is inherent in the general conception. Other examples of the application of these principles, in weighing in preliminary fashion the relative desirability of different general types, will readily suggest themselves.

SALES OF CURTIS STEAM TURBINE-GENERATORS

The following table shows the number and capacity of Curtis steam turbine-generators, of capacities ranging from 1000 to 8000 kw., already installed in commercial service, and under construction, up to Oct. 15, 1906:

Number of Units	Kw.	Total Kw.
13	8000	104,000
2	6000	12,000
38	5000	190,000
25	3000	75,000
3	2250	6,750
44	2000	88.000
51	1500	76,500
44	1000	44,000
220		596,250

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In addition to the above units, over 230 Curtis steam turbine-generators, of capacities ranging from 500 to 800 kw. and aggregating over 130,000 kw., have been installed or are under construction.

These figures do not include a large number of horizontal type Curtis steam turbine-generators, of under 500 kw. capacity, installed and under construction.

RECENT IMPORTANT SALES

Boston Office

Fall River Bleachery, Fall River, Mass.

One ATB 4-500-1800-600 volt Curtis steam turbine-generator.

Lawrence Gas Co., Lawrence, Mass.

One hundred forty one 220 volt, 60 cycle, three-phase induction motors, ranging from 1/4 to 15 h.p. and aggregating about 507 h.p.

Two 4 1/4 h.p. Linotype motors.

Forty-seven 220 volt, 60 cycle, single-phase induction motors, ranging from 1/10 to 3 h.p. and aggregating 34 h.p.

This company formerly used the Edison three-wire direct current system, but its station is gradually being changed to a three-phase, 2300 volt up-to-date plant, and the direct current motors are being replaced by the single-phase and three-phase motors. There have recently been installed in this station two 500 kw., three-phase Curtis steam turbine-generators.

Nashua Light, Heat & Power Co., Nashua, N. H.

One ATB 4-500-1800-T-2300 volt, 60 cycle Curtis steam turbine-generator. This turbine is in addition to two others which were installed some few years ago and have given entire satisfaction which has warranted the purchase of another.

Saxony Woolen Mills, Lowell, Mass.

One ATB 72-600-100-600 volt, 60 cycle generator.

One CLB I 8-35-900-550 volt induction motor direct connected to a CLB 6-25-900-125 volt generator.

One marine engine direct connected to an MP 6-20-360-125 volt compound wound exciter.

One 5-panel switchboard.

Union Street Ry. Co., New Bedford, Mass.

One MP 14-800-100-550/600 volt generator to be used at the main station, as the peak of the station cannot be taken care of under the present conditions.

Philadelphia Office

Alan Wood, Iron & Steel Co., Conshohocken, Pa.

One MP 10-300-150-L-250 volt generator, with panel.

One equalizer pedestal.

Consolidated Gas, Electric Light & Power Co., Baltimore, Md.

One C 4-150-2000-125 volt Curtis steam turbine-generator.

Enterprise Manufacturing Co., Philadelphia, Pa.

One hundred RI 1/2 h.p., 110 volt, 60 cycle motors, less base frames and pulleys—these are to be mounted on coffee mills and meat choppers manufactured by this company.

H. C. Frick Coke Co., Pittsburg, Pa.

For Olyphant Furnace Station, Fayette County, Pa.

One 20 ton tandem locomotive.

Two LM 104-C2-500 volt 42 in. locomotives.

Kanawha Water & Light Co., Charleston, W. Va.

One AQB 4-500-1800-2200 volt, non-condensing Curtis steam turbine-generator, with accessories.

One 12-panel switchboard.

One MP 630-305-125 volt, 80 lb., steam pressure marine generator set.

One motor generator set, consisting of a CL 6-30-720-B-125 volt generator, direct connected to a two-phase, 2200 volt, form K induction motor.

Four Cat. No. 31753 CR regulators, with sprocket chain control.

Two Morris vertical pumps, having a duty of 5,000,000 gal. in 24 hours against 47 ft. head, direct connected to two IQ 10-60-720-K-2200 volt vertical shaft motors, with starting compensators.

Monarch Cotton Mills, Dallas, N. C.

Three H 60-100-10000/20000/40000-575/2300 volt transformers complete, with oil.

One SP ST, 100 amp., 45000 volt non-automatic K-6 oil switch.

One 44000 volt lightning arrester.

Three 60000 volt TD fuses and disconnecting switches.

Pennsylvania R. R. Co., Philadelphia, Pa.

For Altoona, Pa.

One AQB 48-625-B-150-2300 volt revolving field generator.

One motor generator exciter, consisting of a CL 6-50-720-B-125 volt generator, direct connected to an IQ 10-75-720-220 volt motor, with starting compensator and generator rheostat.

Pittsburg Railways Co., Pittsburg, Pa.

For Brunots Island Station, Pittsburg, Pa.

One C 4-150-2000-250 volt non-condensing Curtis steam turbine-generator.

Thirty-seven thousand six hundred ft. three-conductor 0000 cable, varnish cambric insulation, suitable for 15000 volt service, plain lead finish, delivered and installed.

Philadelphia Rapid Transit Co., Philadelphia, Pa.

One LM 101-R2-500 volt 62 1/4 in. gauge locomotive, with cable reel and 500 ft. of cable to be used in shifting cars and car trucks in the car barns and repair shops of this company.

SOUTHERN POWER CO., CHARLOTTE, N. C.

Three H 60-200-10000/20000/40000-575/2300 volt transformers, with low voltage taps.

Chicago Office

CHICAGO & MILWAUKEE ELECTRIC RY. CO., HIGHWOOD, ILLS.

Twenty GE-73 four motor equipments, with Sprague-General Electric type M control.

Twenty 24 ft. air brake equipments for above.

CLARK MONTANA REALTY CO.

For Power Plant at Missoula, Mont.

Two ATB, three-phase, 600 kw., 200 rev. per min., 2300 volt generators.

Two CLB 75 kw. exciters.

Three 500 kw. transformers.

One 6-panel switchboard.

COMMONWEALTH POWER CO., BATTLE CREEK, MICH.

Two ATB 12-200-600-2300 volt BD-2 generators.

Two switchboard panels.

One HT 60-300-4600/2300-460/350/320 volt transformers, with water coil.

This company was the first to purchase the self-excited type of generator, although the above mentioned generators were not the first purchased by them.

THE KENDALL GOLD MINING CO., KENDALL, MONT.

For the Kendall, Mont., Mine.

One fly wheel hoisting equipment as follows:

One fly wheel motor generator set, consisting of one I 10-75-720-M-440 volt induction motor direct connected to a CL 6-90-720-B-500 volt generator. Supported between the induction motor and the D.C. generator will be the fly wheel, whose shaft will be carried by one bearing of each machine and coupled to their respective shafts. This fly wheel will have a capacity of delivering 3,125,000 ft. lb. of work to the generator, with a decrease in speed of 25 per cent.

One automatic regulating rheostat for the 75 h.p. form M induction motor.

One CL 6-100-600-B-500 volt motor, to be geared to the hoist drum.

One MP 6 kw., 720 rev. per. min., 125 volt generator for exciting the D.C. motor and generator. This machine is to be given full voltage with a decrease in speed of 25 per cent, the voltage being kept constant by means of a TD regulator.

One 2-panel switchboard, consisting of an induction motor panel and combination D.C. generator and exciter panel.

As the speed of the hoist motor drops, the automatic rheostat operating in conjunction with the induction motor allows the fly wheel to surrender its stored energy to the generator of the motor generator set, maintaining approximately constant input to the induction motor.

The speed of the hoisting motor itself is controlled through the field of the generator supplying its power, by means of a single lever conveniently located on the hoist.

The system has the advantages of unusually good speed control and of eliminating peaks from the demand in the line.

METROPOLITAN STREET RY. CO., KANSAS CITY, MO.

Twenty GE-80 four-motor car equipments, with Sprague-General Electric type M control.

NORTHWESTERN STATES PORTLAND CEMENT CO.

For the Independence, Kas., plant.

One ATB 28-1000B-107-600 volt, three-phase, 25 cycle, engine driven generator.

ST. LOUIS FROG & SWITCH CO.

For use at the St. Louis, Mo., factory.

One ATB 32-125B-225-240 volt generator.

Eleven three-phase, 60 cycle, 220 volt, form K induction motors, aggregating 215 h.p.

Cincinnati Office

ALLIANCE GAS & ELECTRIC CO., ALLIANCE, O.

One ATB 32-150-225-P-2300 volt generator.

One CQ 11 kw., 800 rev. per min., 125 volt exciter.

This company is at present operating General Electric apparatus exclusively, and placed this particular order without soliciting competitive figures.

CASE MANUFACTURING CO., COLUMBUS, O.

One ITC 5011, 20 h.p., 440 volt, 60 cycle, three-phase induction crane motor.

Three ITC 5009, 15 h.p. induction crane motors.

Two ITC 5003, 4 h.p. induction crane motors.

Four CO 2002, 30 h.p., 230 volt, D.C. crane motors.

This company manufactures cranes and hoisting machinery and specifies General Electric apparatus where it is possible to do so.

CHILLICOTHE ELECTRIC RY. & LIGHTING CO., CHILLICOTHE, O.

Four 50 light series mercury arc rectifier outfits.

One hundred seventy-five Cat. No. 9565/34162 luminous arc lamps.

One 6-panel switchboard.

The contract for the 500 kw. generator which this board is to control was offered to the General Electric Company, but the order was placed with the Fort Wayne Company by request, as sufficiently early shipment could not be promised for a General Electric generator.

S. M. JONES, TOLEDO, O.

Two ATB 32-170-220-480 volt, 60 cycle, three-phase alternators.

Two CQ 11 kw.-1250 rev. per min.-125 volt exciters.

Four MP 6-30-305-L-125 volt engine type generators.

This company manufactures gas engines, and purchases for resale. It is very friendly to the interests of the General Electric Company.

Mahoning & Shenango Ry. & Light Co., Youngstown, O.

Twelve quadruple GE-80 equipments, with K-28 controllers.

Twelve CP straight air brake equipments.

Niles Tool Works, Hamilton, O.

Eight CQ and CR 230 volt D.C. motors, ranging from 3 to 15 h.p. and aggregating 66 h.p.

Two CL, form B, 230 volt variable speed motors, aggregating 45 h.p.

This company manufactures lathes and other wood working machinery, and these equipments are purchased for resale.

Prendergast Lumber Co., Marion, O.

One ATB 12-150-600-P-230 volt generator.

One CQ 55 kw.-1800 rev. per min.-125 volt exciter.

One 2-panel switchboard.

The above order is the initial purchase of electrical apparatus by this company, and the order was placed only after a careful consideration of the apparatus of all competitive manufacturers.

It is understood that this company will in the near future install approximately 300 h.p. in small size induction motors and G. E. representatives have been assured more than ordinary consideration in soliciting this additional business.

Speigel Furniture Co., Shelbyville, Ind.

One ATB 8-100-900-P-240 volt generator, with direct connected exciter.

Two switchboard panels.

Thirteen I, 220 volt, form K induction motors, aggregating 65 h.p.

This equipment will be used in the manufacture of kitchen cabinets and other household furniture, and will be the first installation of this character in the southern part of Indiana.

Stirling Consolidated Boiler Co., Barberton, O.

One 6-panel switchboard.

These panels are to control a 500 kw. Fort Wayne generator, lighting circuits, and several General Electric motors throughout the shops.

The contract for the 500 kw. generator which this board is to control was offered to the General Electric Company, but the order was placed with the Fort Wayne Company by request, as sufficiently early shipment could not be promised for a General Electric generator.

United States Locomotive & Equipment Co., Dayton, O.

Six H 60-100-2000/2200 volt, oil-cooled transformers.

This concern is the holding company for the Dayton Lighting Co., and also acts as Purchasing Agent and Engineers for other of the Brady Syndicate properties.

Denver Office

American Smelters Securities Co., New York, N. Y.

For Utah Copper Co., Garfield, U.

Three ATB 73-2000-100-4000 volt DD-O generators.

One 20-panel switchboard.

One LM 101-B-1 locomotive.

One CL 6-100-600-B-250 volt motor generator.

One I 12-150-600-4000 volt motor generator.

The following 60 cycle water-cooled transformers:

Four 1750 kw. 4000-460 volt.

Three 500 kw. 45000-4000 volt.

Three 300 kw. 45000-460 volt.

Three 200 kw. 45000-460 volt.

Animas Power & Water Co., Colorado Springs, Colo.

For substation at Silverton, Colo.

Three WC 60-1500-47500/38000-17850/15300 volt transformers.

E. I. Du Pont Co., Wilmington, Del.

For Denver Plant, Toluca, Colo. (Powder Mill).

Two ATB 580 volt generators, aggregating 225 kw.

Two GQ 11 kw., 1250 rev. per min., 125 volt exciters.

One TA regulator and miscellaneous transformers, etc.

Twenty-one 560 volt induction motors, aggregating 144 kw.

New England Gold & Copper Mining Co., Bingham, U.

One I 10-100-720-L-440 volt induction motor.

Pueblo & Suburban Traction & Lighting Co., Pueblo, Colo.

One generator panel for 300 kw. 2300 volt generator.

One synchronous motor panel for 300 kw. 2300 volt motor.

One exciter panel for 25 kw. 125 volt exciter.

Sunny Side Mines, Eureka, Colo.

One 10-100-720-L-440 volt motor.

One I 16-110-450-L-440 volt motor.

Three H 60-75-10000/9500-2300/460 volt transformers.

Two switchboard panels.

United States Smelting Co., Bingham Junction, U.

One LM 101-B2-500 volt locomotive.

There Have Also Been Sold:

Eleven D.C. motors, aggregating 171 h.p., and twenty-one A.C. motors, aggregating 415 1/2 h.p.

San Francisco Office

BOSTON MACHINE SHOP CO., OROVILLE, CAL.

The following 440 volt induction motors:

One I 12–150–600 form K (For digging).

One I 8–50–900 form K (Main supply pump).

One I 12–25–600 form K (Main supply pump).

One I 6–25–1200 form M (Winch).

One I 12–25–600 form K (Screen).

One I 6–10–1200 form K (Auxiliary pump).

One I 10–25–720 form K (Stacker).

One I 10–75–720 form K (Sand pump).

Seven type H transformers, aggregating 305 kw.

All of these motors are for Exploration Dredge No. 3. There has also been sold a duplicate of the outfit for Exploration Dredge No. 4.

CENTRAL CALIFORNIA TRACTION CO.,
STOCKTON, CAL.

The following apparatus is for temporary operation by this road pending completion of the permanent 1200 volt apparatus, referred to below, with which the road is to be equipped:

Three four-motor, 75 h.p., 500 volt equipments.

Two motor generator sets, each consisting of a 2200 volt synchronous motor direct connected to a 500 volt D.C. generator. One set will have a capacity of at least 2000 h.p. and the other a capacity of 300 h.p.

Three air compressors.

Permanent apparatus as follows:

Six transformers of 275 kw. capacity each.

Primaries 60000/50000/40000/30000 volts.

Secondaries 2000/2200 volts.

Two 500 kw. motor-generator sets, consisting of a 3-phase, 2200 volt induction motor and DC generators producing 1200 volts.

Six four-motor 75 h.p. equipments complete, equivalent in capacity to the GE-73 railway motor.

These equipments are guaranteed to operate successfully on 1200 volts direct current and 1500 volts maximum.

Six air compressors and governors.

Six pantagraph trolleys.

HOLLAND LAND-WATER CO., STOCKTON, CAL.

Four I 10–75–720–440 volts form K motors.

Four L 4–5–1800–440 volts form K motors.

These motors are installed for the purpose of reclaiming land overflowed during the recent rise in the San Joaquin River.

OAKLAND TRACTION CO., OAKLAND, CAL.

Twenty four-motor GE-70 equipments, with K-6 controllers.

PORTLAND GENERAL ELECTRIC CO., PORTLAND, ORE.

Two HC 12–1000–350–430 volts rotary converters, with switchboard panels.

Six type AB transformers, aggregating 2200 kw.

ST. LOUIS CAR CO., ST. LOUIS, MO.

For Los Angeles Pacific Ry. Co., Los Angeles, Cal.

Twenty-five four-motor GE-73 equipments, with Sprague-General Electric type M control.

SAN JOSE & SANTA CLARA CO. RY. CO.,
SAN JOSE, CAL.

Ten two-motor GE-54 equipments, with K-10 controllers.

Eight four-motor equipments, with 40 h.p., 1200 volt motors, Sprague-General Electric type M control.

Eight combined straight and automatic air brake double end equipments for multiple unit operation, each equipment consisting of one CP, 1200 volt motor driven air compressor.

Four combined straight and automatic air brake double end equipments for trailers schedule operation.

SEATTLE BREWING & MALTING CO., SEATTLE, WASH.

One IQ 14–375–514–2080 volt induction motor.

SEATTLE ELECTRIC CO., SEATTLE, WASH.

Three 1000 kw. AB transformers.

Primaries 13200.

Secondaries 2300/2200.

SISKIYOU ELECTRIC POWER CO., YREKA, CAL.

Two 18–1000–400–2300 volt generators, with exciter sets.

STANDARD BISCUIT CO., SAN FRANCISCO, CAL.

Twenty induction motors, aggregating 140 h.p.

UNITED RAILROADS OF SAN FRANCISCO,
SAN FRANCISCO, CAL.

Two four-motor GE-90 equipments, with K-28 controllers.

One hundred four-motor GE-90 equipments, with K-28 controllers.

WALLA WALLA VALLEY TRACTION CO.,
WALLA WALLA, WASH.

One TC 6–200–1200–600 volt rotary converter.

Three type H transformers, aggregating 125 kw.

Primaries 25000 volts.

Secondaries 370 volts, with AC and DC panels.

Small Motor Department

Ingersoll Rand Co., Phillipsburg, N. J.

Twenty 5 h.p., 220 volt, and twenty 5 h.p., 440 volt, two speed, riveted frame induction motors, for driving drills.

Thirty CQ, 5 h.p., 220 volt motors.

Pittsburg Brewers & Bottlers Supply Co., Pittsburg, Pa.

Twelve CQ, 115 volt motors, ranging from 1/2 to 10 h.p. and aggregating about 44 h.p., to be used for driving beer pumps, bottling and labelling machines, etc., in breweries.

Pond Machine Tool Co., Plainfield, N. J.

Eight CR 7 1/2 (7 1/2 h.p., 500–1500) 230 volts motors.

Eight R-75 controllers and resistances.

These motors and controllers are to be used on machine tools manufactured by this company.

Regina Co., Rahway, N. J.

Seventy FD 1/30 h.p.-1600-115 volt motors.

One hundred eighty UI 1/30 h.p., 1800-110 volt, 60 cycle.

These motors are for operating music boxes manufactured by this company.

H. B. Rust, Providence, R. I.

Nine CQ, 115 volt motors, ranging from 1 to 15 h.p. and aggregating 87 h.p., for use in the factory of the Torrington Mfg. Co., Torrington, Conn., manufacturers of silverware.

THE SLIP OF INDUCTION MOTORS

By A. E. AVERRETT

The slip of an induction motor is the difference between the theoretical synchronous speed of the rotor and its actual speed at a given load, and is usually expressed as a percentage of the synchronous speed. That is:

Full load speed = synchronous speed − slip, or

Full load speed = synchronous speed (100 − per cent slip).

The "synchronous speed" of an induction motor is the speed at which the motor would run on the circuit if it were a synchronous motor, and is the speed which the motor approaches indefinitely, without ever attaining, as the load is reduced toward zero. At this speed, the product of the number of poles of the motor times its speed in revolutions per minute would equal the product of the number of poles times revolutions per minute of the generator supplying the circuit. Thus, if the induction motor had the same number of poles as the generator, its synchronous speed would be the same as the speed of the generator; or, if it had half the number of poles, its synchronous speed would be twice the speed of the generator.

In the operation of the induction motor, the revolving field in the stator causes the rotation of the rotor by setting up induced currents in it. The magnetic field in the stator is revolving at synchronous speed and acts to all intents and purposes like a D.C. field which is revolved mechanically at synchronous speed. If the rotor were held still, there would be large eddy currents induced in it from this revolving field: the slip being 100 per cent. In obedience to the laws of electromagnetic induction, the rotor will tend to revolve at same speed as the field (slip = zero), as by so doing there would be no induction in it from the stator. Thus, at actual synchronous speed, the rotor would have no E.M.F. or current induced in it. When a load is put on, the rotor is slowed down to a greater or less degree, so as to slip, or lag behind the rotating field. The slip thus amounts practically to a certain number of revolutions of the field in excess of the speed of rotation of the rotor—or, looked at the other way about, to a certain number of virtual negative revolutions, relatively to the field, of the positively rotating rotor—causing eddy currents to be set up in the rotor. These eddy currents react against the stator currents, exerting a torque just balancing the counter torque of the load and equal to the product of the flux in the air gap times the energy current in the rotor. Obviously, the greater the load, the more the rotor will lag in velocity behind the velocity of revolution of the field and therefore the stronger will be the currents induced in it. In other words, both the slip and the current taken increase with the load.

The slip is a direct measure of the rotor efficiency. Thus 5 per cent slip means that the aggregate losses in the rotor (copper and iron losses, friction and windage) result in a 95 per cent efficiency of transformation of energy in the rotor.

In expressing the guarantee of an induction motor, the full load slip is always given, along with the efficiency and power factor, for the reason that knowing the slip, number of poles and actual speed, the synchronous speed may be derived without needing to know the frequency.

SLIP INDICATOR

By C. F. HEIZER, Testing Dept.

The Slip Indicator shown in the accompanying illustration was devised by Mr. F. L. Stone, who was until recently assistant foreman of the General Electric Company's Testing Department at the Schenectady Works, and who is now Engineer of the Scranton, Pa., Electric Construction Co. The device is superior to the simple "sector disk" and arc lamp arrangement that had formerly been used by the Testing Department for determining the slip of induction motors, and two of the devices are now constantly in use.

In the sector disk and arc lamp method, the induction motor under test has secured to the end of its shaft, so as to rotate with it, a cardboard disk painted with alternate black and white sectors, there being as many pairs of sectors as there are poles on the motor. With the motor running, the sector disk is observed by the light of an arc lamp fed from the same source of alternating current that supplies the motor. Inasmuch as the light of the arc lamp thus supplied varies periodically in brilliancy from maximum to minimum—the alternationsof brilliancy, and consequently the illumination of the rotating disk, being of course synchronous with the frequency of alternation of the current in the supply circuit—the correspondingly varying illumination of the disk will show, by stroboscopic effect, the relative angular velocity of the disk. For example, if the disk is rotating in synchronism with the generator feeding the arc lamp and motor as described, the sectors will appear to be motionless; but if the speed of the motor is lower than synchronous speed the sectors will appear to be revolving backwards at an angular velocity equal to the difference between synchronous speed and the speed of the motor, i. e., to the slip.

In present-day practice, in testing the complete line of induction motors manufactured at the Schenectady Works, this simple and ingenious method is subject to certain limitations. Except for moderate slips, the stroboscopic effect is difficult to observe quantitatively, the apparent backward revolution of any one sector becoming very baffling to follow when the slip exceeds 40 rev. per min.; while this effect is often interfered with, under ordinary shop conditions, by the difficulty of securing enough difference between the maximum and minimum illumination of the disk.

The Slip Indicator has all the advantages of the sector disk and arc lamp method —in which the operation is differential, relative speed and not actual speeds being observed—and at the same time is free from the practical limitations incident to the optical nature of the former method. This Indicator practically eliminates errors due to "personal equation" by utilizing a mechanical movement, controlled by the frequency of the supply circuit and the speed of the motor under test, to count the slip, instead of observing the actual speeds and taking their difference. The value of this elimination of personal equation is apparent when one considers the chance of large error that is introduced by any method of determining the difference between two relatively large quantitives by observing both quantities and then subtracting one from the other.

The Slip Indicator operates by mechanically comparing the angular velocities of two revolving shafts, one driven at constant speed by a small synchronous motor and the other driven at the speed of the induction motor under test by a flexible connection; recording the difference by the number of revolutions per minute imparted to a differential gear connecting the two shafts.

The arrangement is mounted on a 7 in. by 11 3/4 in. slate base, fitted with a handle at each end for convenience in carrying the Indicator about the shop. In the annexed illustration, the synchronous motor, with a switch and binding posts for connecting it to the supply circuit, appears at the left. The motor is a simple one, having a bipolar laminated field, and a four-pole laminated armature without winding. Its shaft is fitted at one end with a fly wheel and at the other end with a 32-tooth brass gear wheel which may be made to mesh with any one of a nest of gear wheels fixed on a parallel shaft, by shifting the motor on the base of the Indicator. By loosening two knurled screws passing through slots in the brass sole-plate of the motor, the latter may be shifted along to the desired position, exact alignment being secured by removable dowel pins, not shown. The "nest" of gear wheels, any wheel of which may be meshed with the synchronous motor gear wheel, is provided to enable the synchronous motor to drive the parallel shaft at various speeds, thus adapting the Indicator to the testing of induction motors having different numbers of poles.

The parallel shaft, which for clearness of description will be called the "synchronized shaft," is equipped at its right hand end with a bevel gear wheel meshing with the two pinions of a differential gear. Meshing with these pinions on the other side is another bevel gear wheel, carried on a shaft the right hand end of which is equipped with a simple flexible coupling for connection to the shaft of the induction motor under test. This flexible coupling consists of a four-inch length of 3/8 in. round leather belting with four lengthwise cuts to render it flexible, and wound with varnished cloth and tape to stiffen it sufficiently, and fitted at each end with split brass ferrule tips which give a positive, non-slipping connection.

A short auxiliary shaft behind the differential gear has on one end a gear wheel meshing with the large wheel of the differential gear, and on the other end a small hand wheel by means of which this shaft and its gear wheel may be held still. A simple clutch, actuated by a lever which is supported on the base of the Indicator (not shown in the illustration) serves to connect a cyclometer counter with the auxiliary shaft. Inasmuch as the auxiliary gear wheel has one-half the number of teeth of the large differential gear wheel, every revolution recorded on the cyclometer corresponds to two revolutions of the differential gear.

The operation of the Indicator is as follows:

Both full load and no load slips are taken on all motors tested under load. With the load carefully adjusted, voltage normal, and the speed of the driving alternator held at exactly normal frequency, the device is brought up to the end of the induction motor to be tested, and supported in approximate alignment with the motor shaft by means of a portable, adjustable subbase, not shown in the illustration.*

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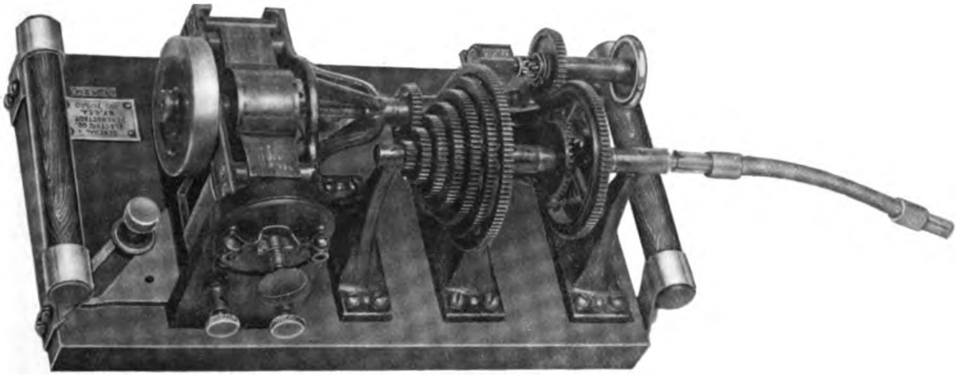
* See the view of a testing squad taking the slip of a 150 h. p. induction motor, on page 20 of the June, 1906, Review (illustration accompanying Mr. E. B. Raymond's article entitled "Commercial Test of Induction Motors").

With the induction motor running at the desired load, the flexible coupling is connected, thus driving the right hand bevel gear wheel of the differential gear at the speed of the induction motor. The synchronous motor is now started by holding the large wheel of the differential gear still, by grasping the hand wheel of the auxiliary shaft; this action causing the right hand bevel gear wheel to drive the left hand bevel gear wheel through the pinions of the differential gear, thereby speeding up the synchronous motor to nearly synchronous speed, so that it "picks up" on being thrown into circuit at the switch. Should the synchronous motor, for any reason, fail to drop into step when its line switch is closed the switch is opened and the whole proceeding gone through again. The operation of starting takes but a few moments, however, one or two trials being generally sufficient to throw the synchronous motor into step.

In the annexed illustration, the gear wheel on the synchronous motor shaft is shown meshed with the gear wheel of the "nest" on the synchronized shaft having the same number of teeth (32); thus adapting the indicator to test the slip of a four-pole induction motor, inasmuch as the rotor of the synchronous motor has four poles. The other gears in the nest have, severally, 16, 48, 64, 80, 96, and 112 teeth, thereby providing for the driving of the synchronized shaft at the synchronous speeds of any and all of the induction motors manufactured by the General Electric Company.

With the synchronous motor running and driving the shaft of the left hand bevel gear wheel at the synchronous speed of the induction motor, through the proper gear wheel of the "nest" corresponding to the number of poles on the induction motor under test, and with the right hand bevel gear wheel driven in the same direction by the induction motor, it will be seen that any difference in speed between the two bevel gear wheels will cause rotation of the differential gear, which will be transmitted to the auxiliary shaft and cyclometer. With the apparatus running as described it is only necessary to "hold the watch" on the cyclometer for any desired interval—usually one minute. In practice, however, the cyclometer is not used, the observer preferring to count the slip by holding his finger lightly against the differential gear so as to count its speed of rotation by noting the contact of each pinion as it passes his finger.



Slip Indicator

SMALL COAL HANDLING PLANT

By C. A. Bray, Cincinnati Office

As an instance of a small installation effecting a marked saving and serving as an introduction for General Electric Company apparatus and methods of engineering to a customer who is likely to purchase other apparatus in the future, the small coal handling plant described herein offers some point of interest.

The Hatfield Coal Co. of Covington, Ky., has a contract to store coal in the storage yard of the Newport Rolling Mills Co., at Newport, Ky., on the Licking River. The coal is brought in river barges to a point near the trestle and is steam hoisted from the barges by a radial arm hoist, the bucket dumping into the side dump trestle car. This car conveys the coal over a trestle radiating in three directions from a central point and comprising about 900 ft. of 35 3/4 in. gauge track, with 20-lb. rails. The type of dump car used weighs, empty, about one ton, and carries a load of three tons of coal.

The car was formerly pushed by hand, and it required six men to handle it: one to dump the bucket, and five to push the car.

After looking over the situation with a view to applying electric drive, it was deviced to equip the car with a motor, and an order was taken for the following apparatus:

Storage Yard of the Newport Rolling Mills Co., Newport, Ky.

For the equipment of the car:

One GE-77 six-turn, 500 volt, railway motor.

One R-28 controller.

Three type PR resistances.

One No. 2 larry trolley.

125 ft. car wiring cable.

One fuse box.

For the trolley line:

One section switch, mounted in a box, to connect the 220 volt power line to the trolley wire.

900 ft. No. 4 trolley wire, with suspension.

No. 4 bonding wire, with channel pins, for bonding the track.

The electrical apparatus on the car weighs something over a ton, making the total weight of the loaded car a little over five tons. By the present arrangement, one man can operate the car and dump the bucket, thereby saving the labor of five men at $1.66 per day, or practically $500.00 for the season of about sixty days required to fill the yard. The electrical equipment cost $535.00, installed. It was possible, therefore, to save practically the entire investment during the first season, which is just closed.

A 500 volt motor was furnished for operating on the 220 volt circuit in order to avoid danger of excessive speed of the car. The speed thus obtained was found to be about right for this class of service.

In the accompanying view of the storage yard, all three branches of the trestle may be seen. The boom of the steam hoist appears over the trestle, at the right of the dump car.

Under the old regime, when the dump car was pushed by hand, the steam hoist was hampered by having to wait for the car to make its trip and come back empty. With the electrically equipped car it is now found that the delay is reversed: that is, the car is usually waiting for the steam hoist.

The customer is entirely satisfied, and is now considering an installation consisting probably of two somewhat smaller equipments, and possibly a small Curtis steam turbine-generator, on the Covington side of the river opposite this Newport installation. It is further hoped that on account of the good record made in this installation, orders will be secured for electrical apparatus for this company's mines.

FEEDER REGULATOR BUSINESS

In the Review for June, 1906, attention was called to the fact that central station managers are beginning to appreciate more forcibly the extreme importance of a close voltage regulation on their feeder circuits. The General Electric Company has of late devoted unusual attention to the development and exploitation of regulators for every condition of feeder service.

Attention is called to interesting articles in the following publications:

Electrical Review for Aug. 13th and Sept. 15th.

Electrical World for Aug. 13th and Sept. 22nd.

Journal of Electricity, Power and Gas for Aug. 11th.

Electrical Age for August.

The last mentioned article is a very complete one, practically consisting of a reprint of Mr. C. W. Stone's address, read before the National Electric Light Association at Atlantic City.

The General Electric Company has distributed the following recent publications bearing on Feeder Regulators:

Feeder Regulator Bulletin No. 4459.

General Electric Company Review for August.

Reprint of Mr. C. W. Stone's paper before the National Electric Light Association.

The lists of sales that follow comprise most of the orders received in the eight months that have elapsed since the beginning of the fiscal year. It is interesting to note the many sales of automatic regulators. Automatic regulation is a most attractive feature to central station men, as it means that the corps of attendants is greatly reduced and that the feeder voltage is kept far more steady than would be possible even by the constant vigilance of an attendant.

IR REGULATORS

Purchaser	Number Sold	Rating	Method of Operation	District Office
Baltimore & Ohio R. R. Co. - - - - -	1	IRH 4- 87 -25	Motor	New York
	2	IRH 4- 36 -60	Motor	Philadelphia
Edison Electric Ill'g Co., Boston, Mass. - - -	2	IRS 2- 11 -60	Hand	Boston
	1	IRS 2- 23 -60	Hand	Boston
Birmingham Ry., Light and Power Co., Birmingham, Ala.	2	IRS 2- 11 -60	Hand	New York
British Thomson-Houston Co. - - - -	4	IRS 2- 12½-60	Hand	Foreign Dept.
Chicago Edison Co., Chicago, Ill. - - - -	9	IRS 2- 24 -60	Motor	Chicago
	2	IRH 4- 44 -25	Motor	Chicago
	25	IRS 2- 18 -60	Motor	Chicago
Cleveland Electric Ill'g Co., Cleveland, Ohio -	46	IRS 2- 7½-60	Motor	Cincinnati
	1	IRT 4- 9 -60	Automatic	Cincinnati
Columbus Ry. and Lighting Co., Columbus, O. -	18	IRS 2- 11 -60	Motor	Cincinnati
Commonwealth Power Co., Jackson, Mich. - -	6	IRS 2- 22 -60	Hand	Chicago
	6	IRS 2- 11½-60	Hand	Chicago
Consolidated Gas Light and Power Co., Baltimore, Md.	1	IRS 2- 22 -60	Automatic	Philadelphia
	12	IRS 2- 24 -60	Automatic	Philadelphia
Detroit Edison Co., Detroit, Mich. - - - -	1	IRT 4- 15 -60	Automatic	Chicago
	10	IRS 2- 25 -60	Motor	Chicago
	4	IRT 4- 76 -60	Motor	Chicago
Empire State Power Co., Amsterdam, N. Y. - -	1	IRS 2- 38 -40	Automatic	New York
French Thomson-Houston Co. - - - - -	2	IRT 4- 19 -25	Hand	Foreign Dept.
	1	IRT 4- 10 -25	Automatic	Foreign Dept.
Fries Mfg. Co., Winston-Salem, N. C. - - -	1	IRS 2- 22 -60	Motor	Philadelphia
Holyoke Municipal Plant, Holyoke, Mass. - -	4	IRS 2- 11 -60	Motor	Boston
Hudson River Electric Co., Albany, N. Y. - -	2	IRS 2- 38 -40	Automatic	New York
Kansas City Electric Light Co., Kansas City, Mo. -	6	IRS 2- 33 -60	Sprocket	Chicago
Lehigh Valley Traction Co., Allentown, Pa. - -	8	IRS 2- 22 -60	Motor	Philadelphia
Los Angeles Edison Co., Los Angeles, Cal. - -	2	IRT 4- 42 -50	Motor	San Francisco
Lynn Gas and Electric Co., Lynn, Mass. - -	1	IRS 2- 60½-60	Automatic	Boston
Mexican Light and Ry. Co., Mexico City, Mex. -	2	IRT 4- 37½-60	Hand	Foreign
Muncie Electric Light Co., Muncie, Ind. - -	1	IRT 4- 26 -60	Hand	Philadelphia
Muskegon Power Co., Muskegon, Mich. - -	1	IRH 4-100 -60	Motor	Chicago
Nashville Ry. and Light Co., Nashville, Tenn. -	2	IRH 4-120 -60	Motor	New York
Nassau Light and Power Co., Nassau, N. Y. -	2	IRS 2- 11 -60	Hand	New York
New Orleans Ry. Co., New Orleans, La. - -	4	IRT 4- 30 -60	Automatic	New York
New York Edison Co., New York, N. Y. - -	1	IRH 4-300 -25	Motor	New York
Oakland Gas and Light Co., Oakland, Cal. - -	3	IRT 4- 50 -60	Automatic	San Francisco
Omaha Electric Light and Power Co., Omaha, Neb.	1	IRS 2- 33 -60	Motor	Chicago
Philadelphia Electric Co., Philadelphia, Penn. -	12	IRS 2- 16½-60	Automatic	Philadelphia
Potomac Electric Co., Washington, D. C. - -	5	IRS 2- 12½-60	Automatic	Philadelphia
Public Service Corporation of New Jersey, Camden, N. J	14	IRS 2- 11½-60	Hand	New York
	8	IRS 2- 12½-60	Sprocket	New York
San Francisco Gas and Light Co., San Francisco, Cal.	6	IRS 2- 11½-60	Hand	San Francisco
Savannah River Power Co., Savanah, La. - -	6	IRS 2- 46 -60	Hand	Atlanta
Sherman, W. V., New York, N. Y. - - -	1	IRS 2- 11 -60	Hand	New York
St. Paul Gas and Light Co., St. Paul, Minn. - -	1	IRS 2- 11 -60	Automatic	Chicago
Stamford Gas and Electric Co., Stamford, Conn. -	1	IRS 2- 16½-60	Automatic	New York
Syracuse Light Co., Syracuse, N Y. - - -	1	IRS 2- 10 -60	Automatic	New York
Tokio, Japan - - - - - - - - -	81	IRS 2- 10 -50	Sprocket	Foreign Dept.
Union Elec. Lt. Co., St. Louis Mo. - - -	1	IRS 2- 22 -60	Automatic	Chicago
Utah Light and Ry. Co., Salt Lake City, Utah -	1	IRT 4-150 -60	Automatic	Denver
Ventura Gas and Electric Co., Ventura, Cal. -	3	IRT 4- 42 -50	Motor	San Francisco
Virginia Passenger and Power Co., Richmond, Va.	3	IRS 2- 11 -60	Hand	Philadelphia
Waltham Gas Light Co., Waltham, Mass. - -	5	IRS 2- 11 -60	Sprocket	Boston
Washington Water Power Co., Spokane, Wash. -	3	IRT 4- 9 -60	Automatic	San Francisco
	1	IRT 4- 5 -60	Automatic	San Francisco
	4	IRT 4- 13 -60	Automatic	San Francisco
	2	IRT 4- 35 -60	Automatic	San Francisco
Wirt, Mfg. Co., H. C., Hanson, Mass. - - -	1	IRS 4-150 -60	Hand	Boston
Yonkers Electric Light and Power Co., Yonkers, N. Y.	4	IRS 2- 22 -60	Sprocket	New York

CR REGULATORS

Purchaser	Number Sold	Rating	District Office
Aurora Elgin and Chicago Ry. Co., Wheaton, Ills. - -	1	CR 60- 5½-2200- 110- 50	Chicago
Connecticut Ry. and Lighting Co., New Briton, Conn. -	1	CR 60-16½-2200- 220- 75	New York
Consolidated Gas Electric Light and Power Co., Baltimore -	3	CR 60- 5½-2200- 110- 50	Philadelphia
Fonger, A. D., Chicago, Ills. - - - - - - - -	1	CR 60-22 -2200- 110-200	Chicago
Foreign Customer - - - - - - - - - -	1	CR 60-22 -2200- 110-200	Foreign Dept.
	5	CR 60-22 -2200 4400-125 160	Foreign Dept.
Harrington, R. S., Attleboro, Mass. - - - - - -	20	CR 60-22 -2200- 110-200	Boston
Kennebec Light and Heat Co., Augusta, Me. - - - -	5	CR 60-22 -2200- 110-200	Boston
Minneapolis General Electric Co., Minneapolis, Minn. -	8	CR 60-22 -2200- 110-200	Boston
New York and Queens Co., Jamaica, N. Y. - - - -	2	CR 60-16½-2200- 220- 75	New York
North Shore Electric Co., Waukegon, Ill. - - - - -	3	CR 60-11 -2200- 220- 50	General Office
North Shore Electric Co., Parkridge, Ill. - - - - - -	3	CR 60-11 -2200- 220- 50	General Office
Rockingham County Light and Power Co., Portsmouth, N. H.	1	CR 60- 5½-2200- 110- 50	Boston
San Antonio Gas and Electric Co., San Antonio, Texas -	1	CR 60-22 -2200- 110-200	Chicago
Sterns Ltg. and Power Co., Liddington, Mich. - - -	1	CR 60-16½-2200- 220- 75	Chicago
Union Electric Co., Dubuque, Ia. - - - - - - -	1	CR 60- 5½-2200- 110- 50	Chicago
United Railways and Electric Co., Baltimore, Md. - -	3	CR 25- 5 -3120- 156- 32	Philadelphia
York Light and Heat Co., Biddeford, Me. - - - - -	3	CR 60-22 -2200- 110-200	Boston

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

The Sao Paulo Tramway. Light and Power Company

(Elec. Rev., Sept. 8, 1906, p. 378)

An illustrated article describing the hydroelectric plant of this company, located on the Tiete River about twenty-three miles from Sao Paulo, Brazil. On account of the great and frequent changes in the level of the river, two dams were built, the reservoir of the second dam acting as a sort of cushion to relieve the strain that would otherwise be brought to bear on the machinery by the sudden changes in pressure. The overcoming of transportation difficulties is interestingly described. The entire equipment was built by the General Electric Company. There are six 2300 volt generators, of 8000 kw. aggregate capacity, and the power is transmitted over four lines to Sao Paulo at 25,000 volts.

The New Hydro-Electric Station of the Holyoke Water Power Co.—II.

[Eng. Rec., Sept. 22, 1906, p. 321]

An illustrated article describing the steam auxiliary equipment of this plant, consisting of a 500 kw., three-phase, 2300 volt, 60 cycle Curtis steam turbine-generator, operating with a Bulkeley barometric condenser of 800 h.p., and a 75 kw. horizontal type Curtis steam turbine-exciter. The station will be operated as a rule by water power, but in the layout of the steam auxiliary apparatus every precaution has been taken to render all of the apparatus serviceable when suddenly called upon in an emergency, the Curtis steam turbine-generators being selected for this reason. Features of the plant are the use of vertical boilers, and the special switchboard arrangements which facilitate the operation of the steam driven and water wheel driven apparatus in parallel.

Port Morris Power Station of the New York Central & H. R. Railroad

[Elec. Wld., Sept. 29, 1906, p. 599;
St. Ry. Jour., Sept. 29, 1906, p. 460]

A very elaborate and detailed illustrated description of this plant. The electrical equipment comprises at present four 5000 kw., 25 cycle, 11,000 volt Curtis steam turbine units and two 150 kw. horizontal Curtis steam turbine-exciters, in addition to a 200 h.p. induction motor driven exciter. The switchboard installation is thoroughly up to date, and comprises a remote control switchboard at the power station gallery and a separate high tension switch house containing all of the high tension apparatus, including the type H oil switches.

Electrical Equipment for the Hudson Company's Tunnel

[St. Ry. Jour., Sept. 29, 1906, p. 467;
W. Elec'n, Sept. 29, 1906, p. 250;
Elec. Wld., Sept. 29, 1906, p. 598]

A description of the electrical equipments required for the twin tunnels of the Hudson Company, connecting Jersey City with New York, under the North River. The traffic in the two single track tunnels will be handled by motor cars equipped with two GE-76 (160 h.p.) railway motors, with Sprague-General Electric type M control, and the current will be supplied from a power station on the New Jersey side, to be equipped with two 3000 kw., and two 6000 kw., 11,000 volt Curtis steam turbine-generators, feeding three sub-stations having an aggregate equipment of eleven 1500 kw. General Electric rotary converters, with the necessary accessories and switchboard installations.

The Newton-Boston Edison Sub-Station

[Elec. Wld., Sept. 29, 1906, p. 602]

The Newton, Mass., Water, Gas & Light Co., which is closely affiliated with the Edison Electric Illuminating Co., of Boston, has recently erected a sub-station in Newton, the architectural features of which were designed to accord with neighboring buildings in the territory supplied, which is one of the most attractive residential districts of Boston's suburbs. Current is obtained from Boston at 6900 volts, but the entire sub-station and line construction is carried out on a 15,000 volt basis in order to be able to increase the output later by increasing the transmission potential. The present equipment comprises three 200 kw., 6900-2300 volt, 60 cycle air-blast transformers, three 50 kw. type H transformers and four 60 light constant current transformers with necessary switches and switchboard apparatus. The entire electrical equipment in the sub-station, illustrations of which are given, was supplied by the General Electric Company.

Alternating Current Motors in a Large Laundry

[W. Elec'n, Sept. 29, 1906, p. 242]

The equipment of the Schriver Laundry Co., Chicago, consists of induction motor group driven washing machines, extractors, ironing machines, starch extractors, and other apparatus, while the largest single machine in the laundry, a mangle, is individually driven by a 2 h.p. motor. All of the motors are 220 volt, 60 cycle, form K machines, started by means of compensators, and are furnished by the Stanley G-I Electric Mfg. Co.

Westport Station of the Consolidated Gas, Electric Light & Power Co., of Baltimore

[Elec. Wld, Sept. 1, 1906, p. 403, and
Eng. Rec., Sept. 1. 1906, p. 234]

A long, well illustrated article describing this new station, which is said to be the largest reinforced concrete station in the world. The station equipment includes four 2000 kw., 25 cycle, 13,200 volt, three-phase General Electric generators and one 500 kw. machine. Full descriptions are given of the construction of the building, accompanied by unusually clear and instructive drawings: of the electric motor operated gantry crane for receiving coal from the adjacent wharf and storage yard, and other coal handling machinery, and of the elaborate filtering plant installed for purifying the feed water.

General Electric Company Review, October, 1906

INDEX

NOTE: In order to save space, the larger number of items reporting sales to Central Station, Traction and Transmission Companies, containing matter of transient interest only, will not be indexed, but may readily be located by looking through the "Recent Important Sales" columns of the REVIEW.

Page

Abstracts of Important Technical Articles ... 111

Bleachery, Fall River ... 100

Boiler Manufacturers:
  Stirling Consolidated Boiler Co., Barberton, O. ... 102

Biscuit Manufacturers:
  Standard Biscuit Co., San Francisco, Cal. ... 103

Brewing & Malting Companies:
  Seattle Brewing & Malting Co., Seattle, Wash. ... 103

Car Builders:
  St. Louis Car Co., St. Louis, Mo. ... 103

Cement Manufacturers:
  Northwestern States Portland Cement Co., Independence, Kas. ... 101

Coal Handling Plant, Small, by C. A. Bray ... 108

Coke Companies:
  Frick Coke Co., H. C., Pittsburg, Pa. ... 100

Cranes and Hoists:
  Case Mfg. Co., Columbus, O. ... 101

Dredging Machinery (See "Mining & Dredging Machinery")

Furniture Co., Speigel, Shelbyville, Ind.

Gas Engines:
  S. M. Jones, Toledo, O. ... 101

Generating Systems:
  Consolidated Gas, Electric Light & Power Co., of Baltimore, Westport Station of the ... 111
  New York Central & H. R. Railroad, Port Morris Power Station of the ... 111
  (See also "Transmission")

Generators, Self-Excited:
  Commonwealth Power Co., Battle Creek, Mich. ... 101

Heating Devices, Electric:
  New Electric Heating Devices in the Home, Some Reasons for the Success of the, by H. W. Hillman ... 93

Hoists (See "Cranes and Hoists")

Indicator (See "Slip Indicator")

Laundry, Alternating Current Motors in a Large ... 111

Locomotive Manufacturers (See "Railway Materials Manufacturers")

Lumber Companies:
  Prendergast Lumber Co., Marion, O. ... 102

Machine Tool Drive:
  Niles Tool Works, Hamilton, O. ... 102
  Pond Machine Tool Co., Plainfield, N. J. ... 104

Mills:
  Cotton Mills, Monarch, Dallas, N. C. ... 100
  Powder Mill., DuPont Co., E. I., Toluca, Colo. ... 102
  Woolen Mills, Saxony, Lowell, Mass. ... 100

Page

Mining & Dredging Machinery:
  Boston Machine Shop Co., Oroville, Cal. ... 103

Mining & Smelting Companies:
  American Smelters Securities Co., New York, N. Y. ... 102
  New England Gold & Copper Mining Co., Bingham, U. ... 102
  Kendall Gold Mining Co., Kendall, Mont. ... 101
  United States Smelting Co., Bingham Junction, U. ... 102

Miscellaneous:
  Silverware Manufacturers: Rust, H. B., Providence, R. I. ... 104
  Wood, Iron & Steel Co., Alan, Conshohocken, Pa. ... 100

Motor Drive:
  Brewers & Bottlers Supply Co., Pittsburg, Pa. ... 104
  Coffee Mills & Meat Choppers: Enterprise Mfg. Co., Philadelphia, Pa. ... 100

Drills:
  Ingersoll Rand Co., Phillipsburg, N. J. ... 104

Music Boxes:
  Regina Co., Rahway, N. J. ... 104
  (See also particular applications, and "Miscellaneous")

Motor Panels (See "Panels')

Motors, Induction, The Slip of, by A. E. Averrett ... 104

Panels, Motor Controlling, Type UY, by W. C. Yates ... 95

Railway Materials Manufacturers:
  St. Louis Frog & Switch Co., St. Louis, Mo. ... 101
  United States Locomotive & Equipment Co., Dayton, O. ... 102

Recent Important Sales ... 100

Reclamation Work:
  Holland Land-Water Co., Stockton, Cal. ... 103

Rectifiers, Mercury Arc, Sales of ... 96

Regulator Business, Feeder ... 109

Slip Indicator, by C. F. Heizer ... 105

Traction:
  Hudson Company's Tunnel, Electrical Equipment for the ... 111

Transmission:
  Holyoke Water Power Co., The New Hydro-Electric Station of the ... 111
  Newton-Boston Edison Sub-station, The ... 111

Sao Paulo Tramway Light & Power Co., The ... 111
  (See also "Generators, Self-Excited")

Turbines and Turbines Installations:
  Sales of Curtis Steam Turbine-Generators ... 99
  Velocities, Aggregate Peripheral, in Steam Turbines of Dissimilar Types, by J. G. Callan ... 98

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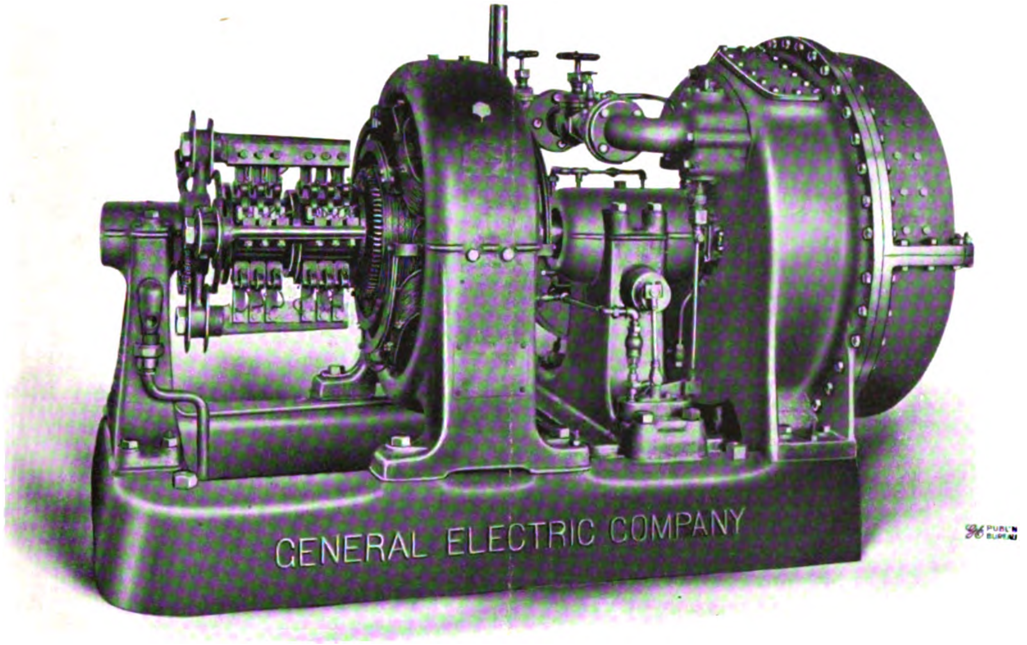
GENERAL ELECTRIC COMPANY REVIEW

Vol. VIII SCHENECTADY, N. Y., NOVEMBER, 1906 No. 1

ELECTRICAL APPLICATIONS ON BOARD SHIP

By J. W. KELLOGG

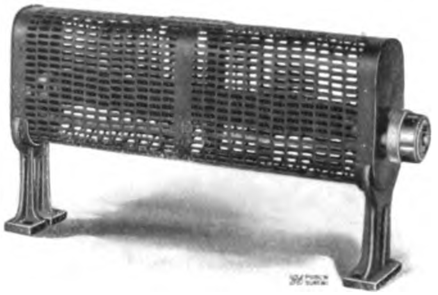
The steamship offers an excellent field for the use of electrical apparatus, a fact early appreciated, as shown by the date of the first installation, on the steamship "Columbia", work on which was started in the summer of 1879 and which was put in operation in May, 1880.



50 KW., 125 Volt Curtis Steam Turbine-Generator

Although this first installation, which consisted of two Edison bipolar machines having a capacity of sixty 10 c. p. incandescent lamps each, proved to be a great success, very little was done to extend the application of electricity to marine work for two years. From about 1882, however, the use of electricity for ship lighting was rapidly extended, and has now become practically universal.

Electricity is actually no less adaptable to many other purposes than it is to lighting, but due to many causes its extension for other purposes than lighting has been slow. The recent great improvements that have been made in electric heating devices, however, and the special adaptability of electric power distribution to the many and various small power purposes on board ship, bid fair to exert no small effect in extending the use of electricity for marine work; especially in the modern ocean liner, with the elaborate appointments which make it a floating hotel, and in the modern warship, with its manifold uses of power as a floating fortress.

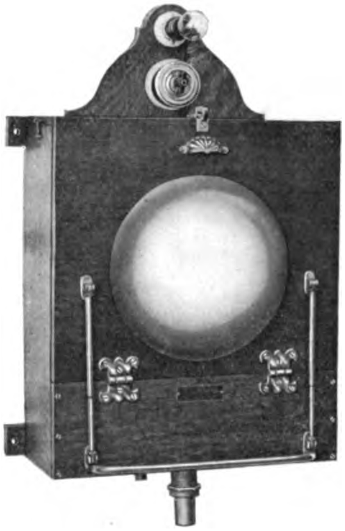


Electric Stateroom Heater

In extending the field of electricity beyond its application to lighting, a most conservative element, which shuns untried things, has to be dealt with. Morever, the extended use of the electric motor has been barred by the expenditure involved for the requisite additional generator capacity, since the power necessary to drive the windlass and steering gear of a vessel is usually in excess of the maximum requirements for lighting. The installation of electric heating devices, however, particularly on passenger steamships, will be an avenue for the introduction of larger generating equipments; for when it can be shown that by the use of these devices many troublesome fittings may be avoided and greater convenience offered to the passenger, the larger generating plants will be provided, and the further application of electric motors for driving auxiliaries will then be simple.

Electric Washstand, Open

To illustrate what has already been done, there are being installed on each of the three new ships now building for the Southern Pacific Company, forty 1800 watt and one hundred and twenty-four 750 watt electic stateroom heaters. The generating plant for these ships consists of two 75 kw. turbine sets and one 10 kw. engine set. There is being developed now an electric heating unit to be used in connection with the washbowls, for providing hot water, which it is thought will be used largely. The installation of these devices will make it unnecessary to run steam or hot water pipes in the passenger quarters. Steam pipes on board ship are always a source of trouble, due to leaks and



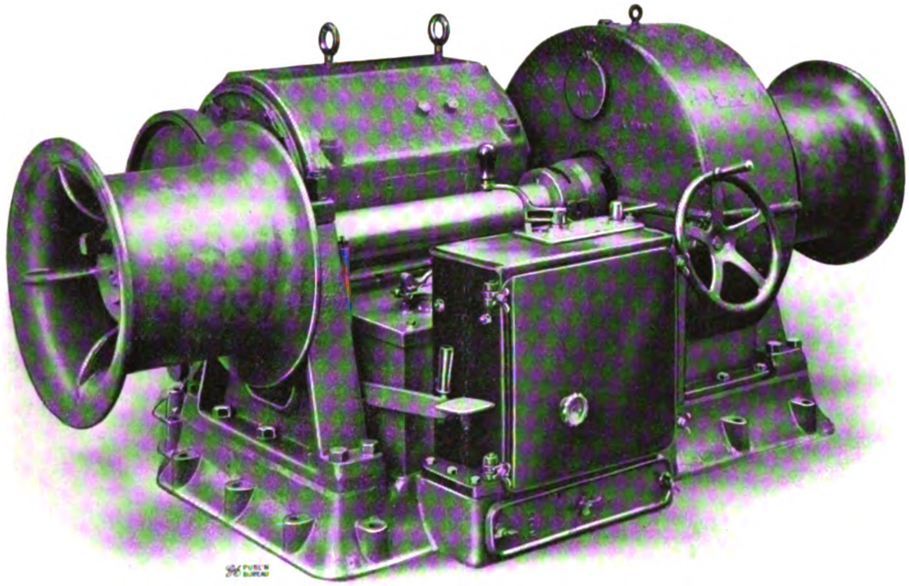
Electric Washstand, Closed

the objectional heating of spaces that do not require it. Much damage results yearly from leaks in steam pipes that are carried through holds.

Electric cooking utensils should prove popular, and there are many electrically driven devices, such as dough mixers, dish washing and laundry machines, etc., in use on ships now. There are also several installations of motor driven deck winches, blowers and ice machines. All of these installations have given the greatest satisfaction.

As the steam turbine is developed for marine service it will have many advantages over the reciprocating engine and tend to allow the installation of much larger generating units. In the ships of the United States Navy comparatively large plants are installed already. The latest battleship has a generating equipment of 800 kw. capacity, consisting of two 200 kw. turbine sets and four 100 kw. engine sets. All turrets, ammunition hoists, boat cranes, deck winches, blowers, and watertight doors are electrically operated, involving the use of 160 motors in all. Over 2150 motors of the CB type have been sold for U. S. naval vessels.

The unusually difficult conditions of marine service, requiring special features of construction—such as non-corrosive parts, and minimum weight and bulk—tend to retard growth. Moreover, as the building of ships in this country is limited for the most part to vessels for the Navy, and for the Coastwise and Great Lakes trades, the field is not as broad as desired to keep costs at a minimum. While the campaign in favor of a subsidy bill has made progress toward the ultimate end of favorable legislation for the upbuilding of the American Merchant Marine, the delay in such legislation has tended to restrain new capital from entering the field. As soon as the rapid development of the Merchant Marine is inaugurated, a corresponding growth of a profitable and important branch of the electrical industry will be assured.



Electrically Driven Deck Winch

EXPERIENCES WITH A TIRRILL REGULATOR IN THE ELECTRICITY WORKS AT WELS (AUSTRIA)

A paper read by Director Klicpera, before the Austrian Association of Electricity Works, printed in "Electrotechnik und Maschinenbau", Sept. 23, 1906, p. 764, describes an interesting demonstration of the value of the Tirrill Regulator in securing good voltage regulation under unusually difficult conditions.

The small water power plant at Wels supplies about 1200 incandescent lamps and 50 h. p. in small motors, in addition to about 300 h. p. in motors installed in a paper and pulp factory. The transmission line to this factory is about 10 miles long, and its load fluctuations range between 50 and 300 kw., as shown by a recording wattmeter chart, reproduced in the annexed illustration, Fig. 1. Under these conditions the switchboard attendants were unable, even with the most careful work, to obtain better voltage regulation than that shown in the recording voltmeter chart, Fig. 2: in which it will be

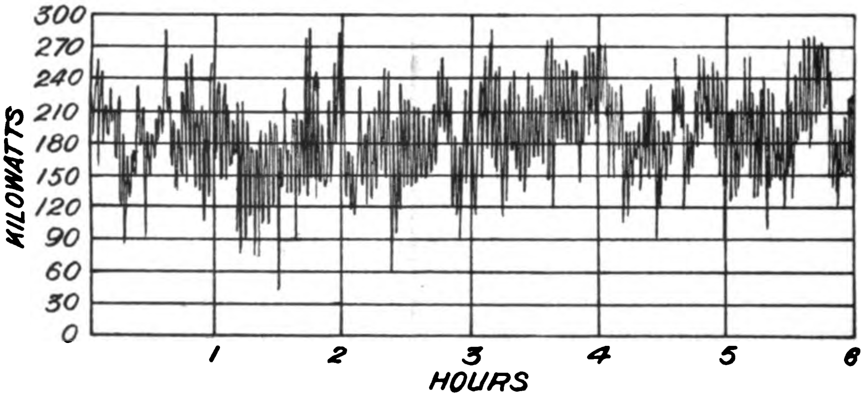


FIG. 1
Recording Voltmeter Chart Showing Variation of Load on Wels (Austria) Transmission Line

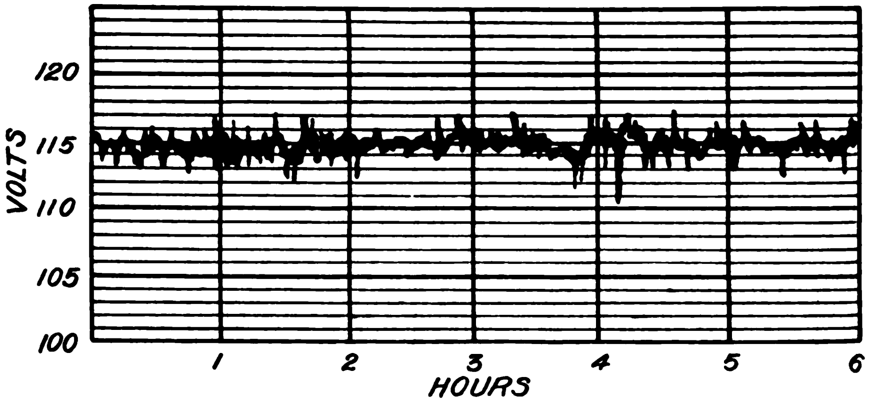


FIG. 2
Chart Showing Voltage Regulation Obtained at Wels by Hand Regulators Operated by Switchboard Attendants.

noted that voltage fluctuations ranging between 110 and 118 volts were not eliminated.

Such poor regulation, and the strain put upon the switchboard attendants to obtain even this unsatisfactory result, caused the works management to try automatic regulating devices, and an electro-magnetically operated automatic rheostat was installed. This device relieved the switchboard attendants, but did not improve the regulation to the desired amount, as will be noticed by inspection of the voltmeter chart, Fig. 3. The inherent time lag of the electromagnetic rheostat prevented the device from following the load fluctuations rapidly enough, and the management decided to try a Tirrill regulator.

The Tirrill regulator has now been in use for one year, during which period it has been in constant service without any failure, and without requiring any attention

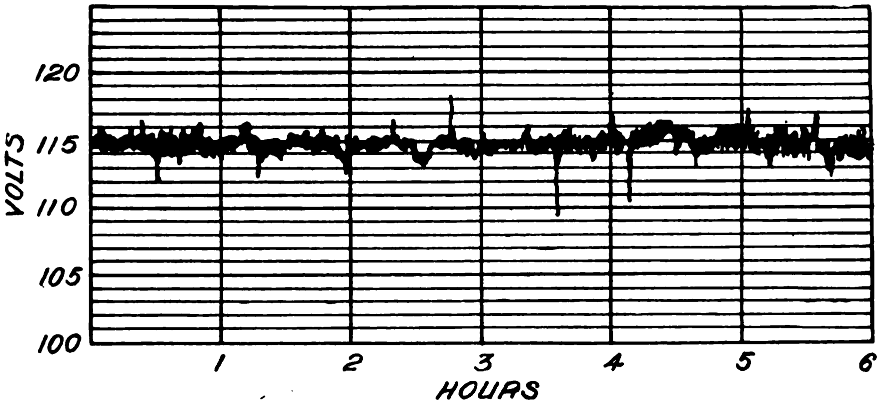


FIG. 3
Chart Showing Voltage Regulation Obtained at Wels by Electromagnetically Operated Automatic Rheostat

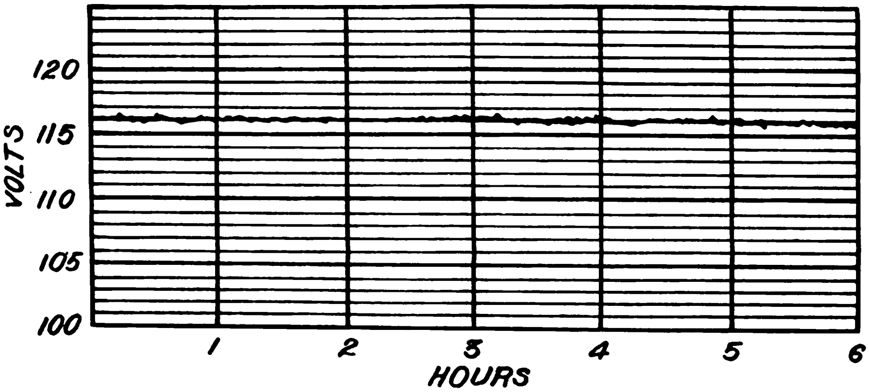


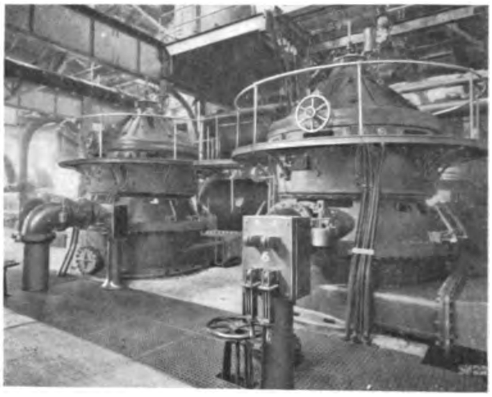
FIG 4
Chart Showing Constant Potential Obtained at Wels by Tirrill Regulator

whatever beyond the occasional cleaning of the short-circuiting contacts with emery paper. Constant potential is obtained, as shown in Fig. 4, notwithstanding the large load fluctuations, and without requiring any help from the switchboard attendants. As a result of this experience, Director Klicpera warmly recommends the use of Tirrill regulators for electricity works laboring under objectionable potential fluctuations due to heavy load fluctuations.

It will be recognized that parallel conditions exist in this country, in which there are many more combination lighting, power and railway plants than there are abroad. A comparison of the charts herewith, Figs. 2 and 3, shows clearly that the best results possible to obtain with a regulator of the automatic rheostat type do not surpass careful hand regulation. Further, a comparison of these charts with the TA regulator chart, Fig. 4, shows conclusively that neither hand nor automatic rheostat regulation can, in the nature of things, be expected to equal the results obtained by the Tirrill regulator method. That is to say, no rheostat and switch arm arrangement, whether hand operated or automatically operated, can be in the same class, mechanically or electrically, with the light, continuously operated contact-making device of the Tirrill regulator, rapidly opening and closing a shunt circuit across the field rheostat in sensitive response to all changes of load or speed.

LOW PRESSURE CURTIS STEAM TURBINE GENERATORS

The Electric Railway Review for August, 1906, contains on page 459 an illustrated article describing the 800 kw., 500 volt low pressure Curtis steam turbine-generators which are installed at the Thirteenth and Mt. Vernon St. Station of the Philadelphia Rapid Transit Co., and which have been in service since December, 1905, and February, 1906, respectively. These turbine-generators, which are shown in the annexed illustration, are supplied with exhaust steam from reciprocating engines, and operate successfully in parallel with engine driven units.



C 6-800-1200-575 Volt Curtis Steam Turbine-Generator Installed for Operation on Exhaust Steam from Reciprocating Engines at the Generating Station of the Philade phia Rapid Transit Co.

For other accounts of these low pressure Curtis steam turbine-generators, the reader is referred to the following articles:

Power, March, 1906, page 150.
Canadian Engineer, June, 1906, page 211. Editorial Note, page 230.
Canadian Engineer, September, 1906. Editorial Note, page 338.
Electric Railway Review, August, 1905, page 465, Editorial on page 459.
Railway & Engineering Review, March 10, 1906, page 160, Editorial in issue of Feb. 10, 1906, page 97.
Engineer, August 17, 1906, page 175.

A 500 kw., 500 volt Curtis steam turbine-generator, operating on exhaust steam, has been in service at the plant of the Scranton (Pa.) Railway Co. since May 1, 1906.

COMPRESSED AIR IN THE IRON FOUNDRY

By C. L. Prince

The Iron foundry at the Schenectady Works (Building 83) has grown rapidly with the general growth of the Works, and is now equipped to handle an immense output, as shown by the following figures:

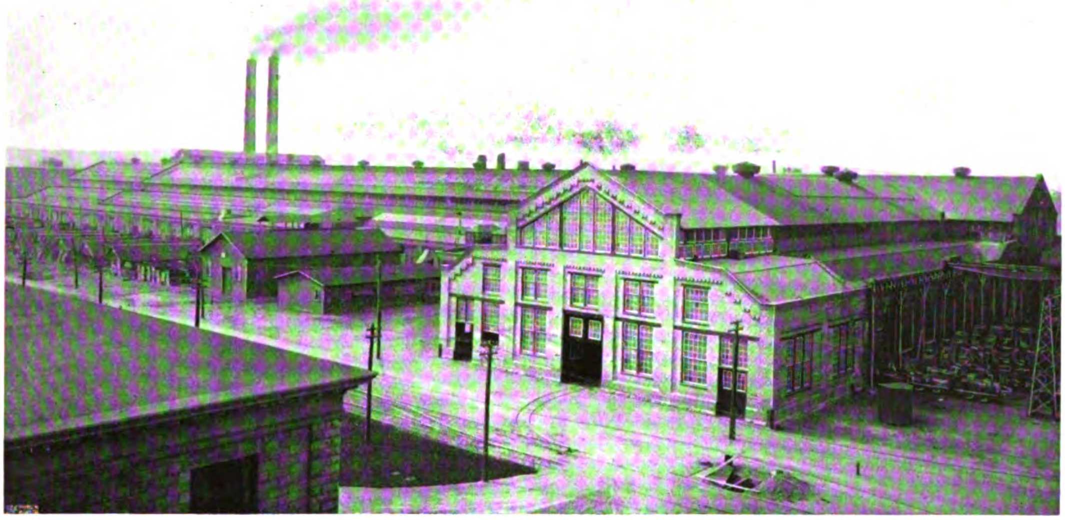


FIG. 1

General View of Iron Foundry at Schenectady Works (Building 83)

Number of employees	1,030
Square feet of floor space......	214,000
Number of cupolas	5
Tons of castings produced per week, about	550
Number of castings produced per week, about	45,000

The accompanying general view of the iron foundry, Fig. 1, shows the additions recently completed to the main building and cleaning room wing (making the main building 880 ft. by 140 ft. and the wing 170 ft. x 120 ft.) and the gantry crane which covers the 50 ft. by 450 ft. flask storage yard.

Among the many labor saving methods that have been adopted at the iron foundry, the use of compressed air is one of the most important. Compressed air is utilized in one way or another in nearly every one of the operations connected with the making of the finished castings. The air is used at 80 lb. pressure, supplied through the general Works system of underground compressed air pipes by a number of electric motor driven compressors of various capacities, installed throughout the Works. A compressor of 1700 cu. ft. per min. capacity driven direct by a 225 h. p., 10,000 volt

ATI synchronous motor* (Fig. 2), is installed in Building 83, and renders the iron foundry supply independent of the general service—to which this compressor is, however, ordinarily connected. It is well known that electric distribution exclusively is used at the Schenectady Works, electric motors being installed for either "individual drive" or "group drive", according to requirements. Such group drive is usually carried out by installing a single motor to drive a line shaft to which the various machines are connected.

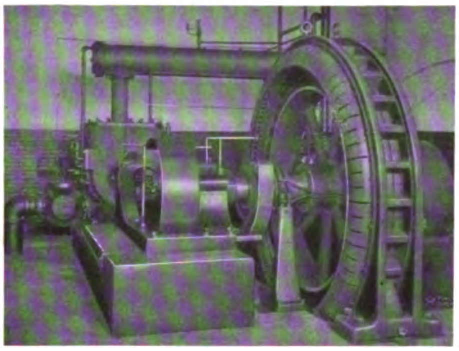


FIG. 2

1700 Cubic Feet Per Minute Air Compressor, Driven by 225 H. P. 10,000 Volt Synchronous Motor

The peculiar condition of foundry work, in which the operations are intermittent, and scattered in location, render the use of compressed air advantageous for many small power purposes. The compressed air devices in Building 83 may be regarded as a special group drive installation supplied by the electric motor of the air compressor set: the compressed air being the medium through which the electric power is applied to the various operations.

One of the most interesting applications of compressed air, and the first such application in the sequence of iron foundry operations, is to the sixty-three Tabor molding machines, one of which is shown in Fig. 3. These machines are in constant use for making molds from a great variety of the smaller patterns, including the majority of the iron patterns for castings up to 100 lb. weight, although many castings up to 1000 lb. weight are also made on these machines.

In the making of molds by the Tabor machine, the compressed air serves three purposes. For ramming the sand about the pattern, the air is piped to an inverted vertical cylinder (the plunger of which is fixed) in the lower part of the machine. With the pattern in place in the "drag" or lower part of the flask, or in the "cope" or

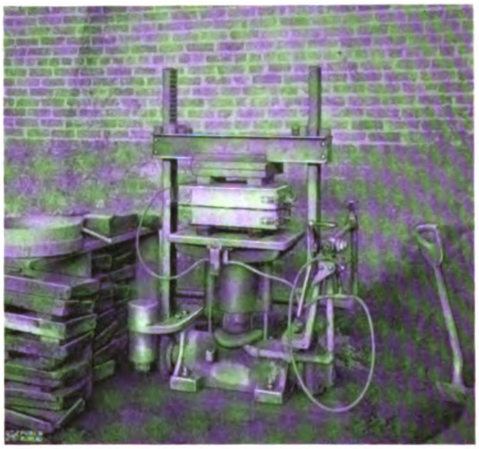


FIG. 3

One of the Sixty-Three Molding Machines in the Iron Foundry, Operated by Compressed Air upper part, as the case may be, the workman operates a lever valve, admitting air below the cylinder, so as to strike upward blows of controlled force on the bottom of the flask. Two or three blows, delivered in this way, thoroughly tamp the sand about the pattern as well as it could be done by hand, and with great saving of time. Another valve is then opened, admitting air to the "vibrator", which sharply raps the side of the pattern, neatly and quickly loosening the pattern from the sand so that it may be lifted out of the mold. The third use of the air in this machine is to blow the loose sand away from the mold.

---

*The ATI design permits the use of synchronous motor drive for this air compressor, thereby securing the advantages of 10,000 volt A. C. distribution. In motors of this design the squirrel-cage winding, which is threaded through the revolving field, gives sufficient starting torque to overcome the friction and inertia of the compressor. Although the compressor is equipped with an automatic "unloading device" which relieves the pressure on the pistons at starting, the load on the motor at starting could not be picked up by a synchronous motor of the ordinary type. By using the squirrel-cage auxiliary winding, however, good starting characteristics, essential to the operation of a motor driven air compressor, are obtained, and at the same time the economical running characteristics of the synchronous motor for this intermittent load are realized.

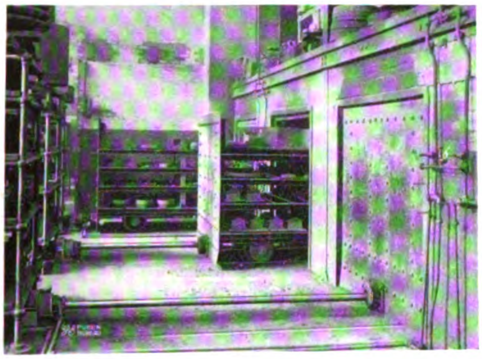


FIG. 4

Core Ovens Operated by Compressed Air

There are eight of these core ovens in the iron foundry. The view shows three of the ovens, the one in the foreground being closed. The other two have their cars, loaded with cores, partly and fully withdrawn, respectively, from the oven. The compressed air for pushing the cars into and out of the ovens is controlled by the valves at the right.

Compressed air is used in an entirely different way in connection with the large core ovens, of which there are eight in this iron foundry. Fig. 4 is a view of three of these core ovens. The car of each oven runs on rails, and is fitted with a shield at each end for closing the oven when the car is either in or out of the oven. Compressed air, acting on a 5 in. piston in a long horizontal cylinder in front of the oven, operates the car through a piston-rod engaging in a loose T joint in the outer end of the car. When the car has been loaded with "green" cores, the opening of a valve admits air behind the piston, pushing the heavy car into the oven; the load being withdrawn when the cores are baked by opening another valve which admits the air to the other side of the piston. The simple, direct acting arrangement described, requiring practically no attention and with nothing to get out of order, is well adapted to meet the unavoidable conditions of dust and rough handling in the iron foundry.

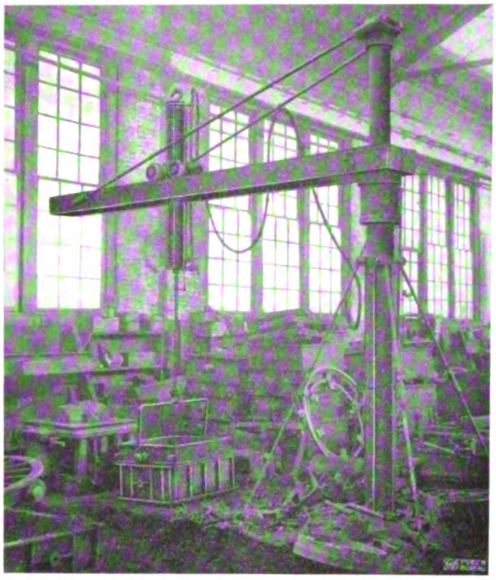


FIG. 5

Jib Crane Equipped with Compressed Air Cylinder

The compressed air cylinder gives a positive but perfectly smooth control of the load on the crane, and is especially useful in assembling the different sections of a flask easily and quickly, without danger of injuring the mold by sudden movements or jarring.

Another application, illustrating equally well the inherent durability of compressed air devices for the severe conditions of iron foundry work, is to be found in the small lifting cylinders with which a number of jib cranes are equipped (see Fig. 5), and which greatly facilitate the work of handling the flasks, by giving a wide range of lifting and lowering speeds, with singularly smooth operation.

The blowers for supplying forced draft (air blast) for the cupolas in which the various kinds of pig iron are melted, and the heating and ventilating fans, are to be mentioned in passing, as they come legitimately under the head of "compressed air".

The castings, when removed from the molds, are subjected to further treatments by compressed air: in the sand blast apparatus (Fig. 6), which removes mold sand adhering to the castings; and in the pneumatically operated chipping tools, by means of which the castings are dressed into shape for delivery to the machine shops.

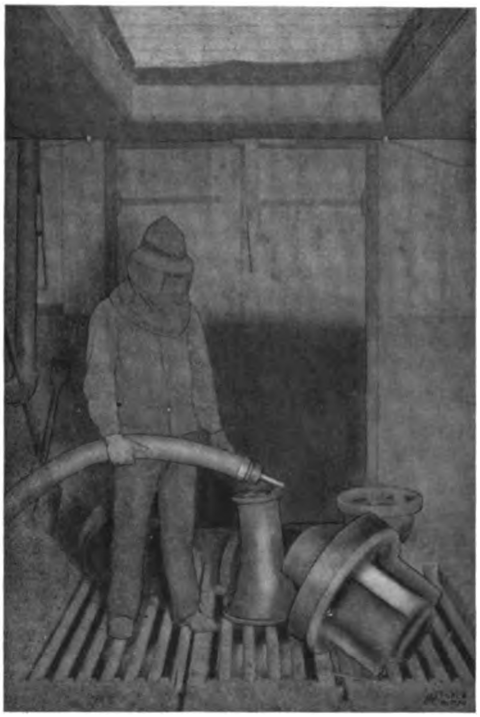


FIG. 6

Sandblasting the Castings to Remove Adhering Sand

THE TESTING OF D. C. CIRCUIT BREAKERS

By F. L. KEMP, Engineering Dept.

In common with every piece of apparatus and machinery that is manufactured by the General Electric Company, the D. C. circuit breakers, which are made in Building 23 of the Schenectady works, are thoroughly tested as a regular part of the manufacturing routine: a "Special Test" being applied to one or more breakers of every new type that is put into production, and the "Standard Test" being applied to every individual breaker that goes out of the Factory.

In applying the Special Test, the breaker is set up in its normal vertical position and the rated current is passed through it until the temperature of all parts, indicated on a number of thermometers, reach constant value. In this way the maximum temperatures attained by the main break and secondary breaks, and of the conducting part between each break and the body of the circuit breaker, are determined as well as the temperature of the overload trip coil, low voltage and release coil, and other current carrying parts. The Special Test also includes calibration of the overload trip at all adjustments at which the breaker may be set to operate. The accompanying illustration, Fig. 1, is a view of a circuit breaker undergoing Special Test.

For testing circuit breakers, the following five low voltage, high amperage generators are installed in Building 23, one or another of these machines being used according to the size of the breaker under test:

One 4 kw. machine, giving 1000 amp. at 4 volts.

One 24 kw. machine, giving 400 amp. at 60 volts.

One 32 kw. machine, giving 4000 amp. at 8 volts.

One 36 kw. machine, giving 600 amp. at 60 volts.

One 400 kw. machine, giving 40,000 amp. at 10 volts.

These generators are all separately excited from the 125 or 250 volt shop circuit, through a field rheostat as shown in the diagram of connections, Fig. 2. The larger machines are connected by very heavy leads to a number of testing stands conveniently located.

In putting circuit breakers through the Standard Test, the breakers, whether to be ultimately mounted on individual bases or on switchboard panels, are brought in mounted on temporary wood bases, giving a lighter piece of apparatus to handle and facilitating rapid testing. Moreover, the inevitably large amount of handling that the breakers receive in being put through this test would be liable to deface the permanent slate or marble bases, on which the breakers are mounted before shipment.

Arrived at the testing stand, the circuit breaker is secured in its normal vertical position on an adjustable rack adapted to the handling of breakers in rapid succession. The heavy leads from the generator are connected to the terminal studs of the breaker, and the current is thrown on, beginning at a strength lower than that required to trip the breaker. The current is gradually increased by operating the field rheostat of the generator, the observer noting on the ammeter the current at which the breaker trips and making the necessary calibration adjustments. All overload breakers have a set of calibrations, or positions of the armature corresponding to different tripping currents. For example, the type C, form P, 500 amp., 650 volt breaker is calibrated for 300, 400, 500, 600, and 750 amp.

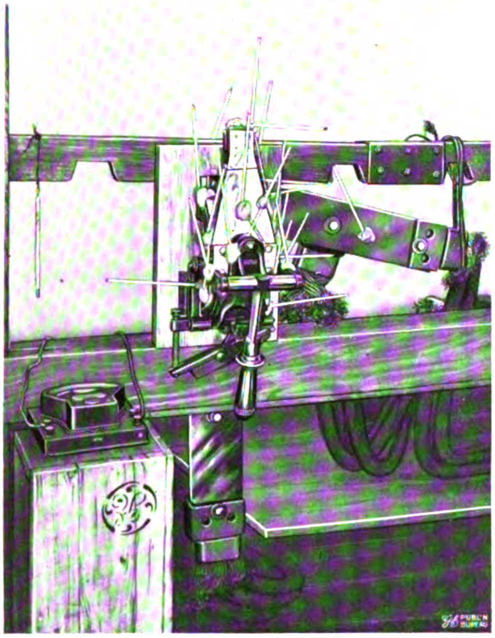


FIG. 1
Type C Form K, 4000 Amp., 250 Volt Circuit Breaker Undergoing the "Special Test"

The circuit breaker is being given a heat run of six hours, with a thermometer applied at every current carrying part.

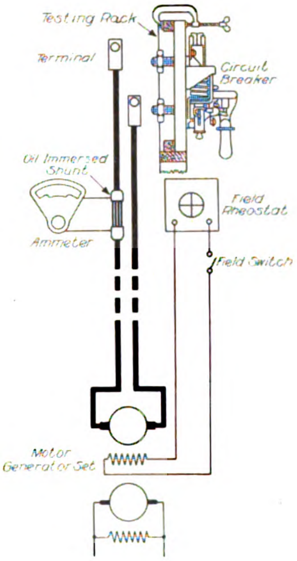


FIG. 2

Connections For Testing D. C. Circuit Breakers

Over five hundred circuit breakers of all types and sizes are tested each week at the Schenectady Works.

MR. P. T. HANSCOM'S NEW WORK IN CENTRAL COLORADO POWER DEVELOPMENT

Mr. P. T. Hanscom resigned from the General Electric Company October 1, 1906, to become associated with Messrs. Curtis & Hine, of Colorado Springs, and will have charge of the electrical engineering work and assist in the management of the various hydro-electric plants now operated and to be constructed by them.

The greater part of Mr. Hanscom's time for the next two years will be devoted to electrical engineering in connection with the Central Colorado Power Company, which was recently organized for the development of about 100,000 horse power on the Grand River and other Colorado rivers. On the Grand River, which runs through the central part of the State, there is an opportunity to develop large water powers at comparatively low cost of development and within practicable transmission distances from points where considerable power is required. The Grand River is the largest river in Colorado, and has the most extensive and reliable drainage area, consisting largely of mountain ranges on which there is a heavy precipitation and a large run-off. The river has two abrupt decents, one at Gore Cañon and one near Glenwood Springs, and the topography of the watershed is such as to admit of the building, without undue cost, of storage reservoirs of sufficient capacity to equalize, to a great degree, the flow of the river.

The Central Colorado Company will have an authorized bond issue of $20,000,000.00, the first issue of which, $9,000,000.00, has already been subscribed. Power will be delivered to Denver, and to important mining centers of Colorado, such as Leadville, Cripple Creek, Aspen, Georgetown, Idaho Springs and Central City.

The project is of more than usual interest, since the transmission lines will ultimately cover an area of approximately 50,000 square miles, on the eastern and western slopes of the Continental Divide. On account of the large amount of power to be transmitted, and the large area of distribution, a primary potential of about 100,000 volts will be employed. Arrangements are being completed for starting construction work immediately.

Central Colorado offers an exceedingly attractive power market for an enterprise of this kind, since the use of power in this territory is large and increasing rapidly, and the cost of power is unusually high. The territory which can conveniently be supplied from the plants contemplated, with transmission lines well within permissible length, comprises an area of about 50,000 square miles in the central part of Colorado, extending from Denver on the east to Grand Junction on the west. This territory is very rich in mineral, agricultural and other natural resources, which have already been developed to a considerable extent, but which are susceptible of much greater development. It has a large and rapidly increasing population, including more than twenty cities and towns aggregating over three hundred thousand inhabitants, of which Denver, with a population of nearly 200,000 is the largest.

The most productive mining camps in the State are comprised in this area. Statistics show for this territory, an output of nearly $900,000,000.00 in metals, chiefly gold, silver, lead, copper and zinc—up to the present time, and the annual output is steadily increasing.

Mr. Hanscom entered the expert course, Thomson-Houston Company, Lynn, in January, 1893, and was transferred to the Power Transmission Dept., under Dr. Louis Bell, in May of the same year. In September, 1895, he was transferred to Schenectady, under Mr. F. O. Blackwell, who was then Engineer of the Power & Mining Dept. On the resignation of Mr. Blackwell from the General Electric Company, in November, 1904, Mr. Hanscom was appointed Assistant Engineer in charge of the Power & Mining Dept.

NOTES

Mr. C. I. Burkholder who has for some years been Mr. Rohrer's able assistant, has resigned to take the position of Manager of the Operating Dept. of the Southern Power Company, with headquarters at Charlotte, N. C. His work will be largely among cotton mills, and the plans of the Company involve the engineering and distribution of many thousand horse power developed at a number of hydro-electric power plants, actually completed, and projected, on the Catawba River. The district which will be covered by the lines of the Southern Power Company now contains steam power plants aggregating 200,000 h. p., largely in cotton mills: 50 per cent of the cotton spindles in the south being located within 100 miles of Charlotte and well within the distribution area of the Southern Power Company.

Sales of apparatus to the Southern Power Company have been reported from time to time in the REVIEW.

Mr. E. W. Robinson recently returned from an extended vacation at his old home in London, England.

Mr. D. B. Rushmore was appointed engineer of the Power and Mining Department last month. He has been with the General Electric Co. for some two years, during which time he has been successively connected with the Railway Engineering Department and the Power and Mining Department. Before coming to Schenectady, Mr. Rushmore was in charge of the Alternating Current Design with the Stanley Electric Mfg. Co. at Pittsfield, Mass., and has had extensive experience in Alternating Current Transmission Work.

He is a prominent member of the American Institute of Electrical Engineers, having presented several papers before that body, and as Chairman of the Schenectady branch, has been actively interested in local institute affairs. He brings to his present position a thorough knowledge of the details, together with administrative and executive ability.

Mr. Joseph B. Baker, who has for the past two and a half years occupied the position of assistant editor of the General Electric Review, has left the company to accept the position of Technical Editor of the Government Fuel Testing Plant at St. Louis, Mo. He is succeeded by Mr. J. M. Knox of New York.

Mr. W. S. Wright is at Pittsburg, inspecting a large order of steel towers for a South American high tension transmission.

Mr. J. A. Seede and Mr. G. A. Maier, of the A. C. Engineering Dept., Mr. G. A. Brebner, of the Switchboard Engineering Dept., and Messrs. A. L. Jones and C. B. Kimball, of the Testing Dept., are among those who have recently been added to the office force.

Mr. A. R. Bush, formerly local engineer of the Boston office, is now again connected with the Boston office in the capacity of general salesman in the Power Dept. He is to give special attention for the present to Paper Mill work, and as he is probably as well acquainted with this class of work as anyone in the Company, his services in this line will be very valuable. Mr. Bush would be very glad to assist any of the other District Offices at any time in this branch of work, whenever such assistance can be of value.

Mr. W.M. Rand has been giving attention recently to the equipping of shoe shops, and through his wide acquaintance with the shoe manufacturers has extended his territory even down into Virginia, and recently sold plants for equipping three large shoe factories at Lynchburg, Va.

Mr. C. B. Burleigh is now wholly occupied in the exploitation of the Curtis steam turbine-generator, and assists in demonstrating the advantages of the Curtis turbine in the various negotiations in which the representatives of the Boston Office are engaged. In addition to this special work, he has given a great many talks before Engineering Societies and Clubs, and recently read a paper at the Annual Meeting of the New England Cotton Manufacturers Association at Hotel Champlain. Mr. Burleigh is pretty well posted on turbines and can be of assistance to almost any of our representatives. His enthusiasm for and confidence in the Curtis turbines are stronger than ever.

Mr. R. Neil Williams, formerly connected with the Foreign Dept. in Schenectady, has recently joined the Boston Office force in the Power & Mining work, and is now devoting his time to the seeking of new business, a branch which in the rush of old business during the past year the regular agents have not had time to attend to. Mr. Williams has been in Schenectady for some time and has been assistant to Dr. Steinmetz in giving lectures at Union College.

Mr. C. W. Hough, who has represented the Chicago office Power & Mining Dept. at Kansas City, has resigned to take the position of Manager of the Consolidated Light, Power & Ice Co., of Joplin, Mo. Previous to his entering the selling organization, Mr. Hough was an expert for the Chicago office and had charge of some very important installations, among which was the large plant of the Metropolitan Street Ry. Co. of Kansas City, Mo. Mr. Hough had entire charge of this plant and made a most excellent record in connection with it.

Mr. A. W. Paine, who has been with the Chicago office Power & Mining Dept. since 1899, has been transferred to the Kansas City office as representative of the Power & Mining Dept. there. This change is much to the regret of his associates in the Chicago office, who will miss his genial good humor and companionship.

Mr. G. E. Guy, of the Power & Mining Dept., Schenectady, will hereafter be connected with the Helena office of the Company, with headquarters at Butte, Mont.

SALES NOTES

The following order was placed with the Boston Office of the General Electric Co. by the Great Northern Paper Company, Millinoket, Me.

Two ATB 14–800–343–6600 volt generators,
Two MP 8–30–343–125 volt exciters,
One ABT 40–300–6600–575 volt transformer,
Two ABT 40–1000–6600–575 volt transformers,
One 35 in. fan with an I 6–1–800 form K, and 2–55 in. fans with I 6–4–800 form K,
Twenty-four 40 cycle induction motors aggregating 2102 h.p.

This equipment is to be used in a distinctly modern installation which is an extension of a former one made by the General Electric Company for this concern at the Millinoket (Me.) mill in 1900. This earlier equipment consisted of three ATB 1000 kw. 400 h.p. 600 volt generator and a number of induction motors having a total capacity of about 4000 h.p.

In addition to the installation at the above mill, the General Electric Company installed a 900 kw. plant at Madison, Me., thus making a total equipment amounting to 65000 kw. generating capacity furnished to the Great Northern Paper Company, together with an equivalent number of motors, switchboards, exciters, etc.

* * *

The Indiana Steel Company, Chicago, Ill., has ordered six 25 cycle form LM induction motors aggregating 24000 h.p., six complete control equipments, and a switchboard of six three phase motor panels. These are to be used in the Company's new plant at Gary, Ind., which is designed to have an output of 2,500,000 tons of steel annually.

This is the first steel plant in the United States to operate its rolls by induction motors, probably the most severe work to which motors can be put, the entire load being thrown on instantly subjecting the machines to sudden excessive strain. The induction motor is, however, peculiarly adapted to work of this nature, for in addition to the absence of commutator and sparking, the rotor can be built like one solid piece, thus enabling the machine to withstand the severest strains without injury. The motors in this equipment are of especially massive construction, are designed for 50 per cent over load and carry each a heavy fly wheel; they are controlled by contactors which are operated by a master controller, and to assist the motor in case of over load, transformers are placed in the motor circuit which in event of excessive motor current, energize "slip relays" that cut resistance into the three phases of the rotor circuit thereby reducing the speed and permitting the fly wheel to return energy to the motor. There are two of these relays designed to operate at different load values.

This is the first time that this slip relay device has been used in this country.

* * *

The Universal Portland Cement Company has placed an order with the Chicago Office of the General Electric Company for 240 25 cycle induction motors, having a total capacity of 9400 h.p. These motors are to be divided between their plants 4 and 5, the first being at the Illinois Steel

Co. at Buffington, Ind., and the second at the Carnegie Steel Company's Works at Pittsburg, Pa. The principal features of this order are: Fifty-one 100 h.p. motors of 166 r.p.m. to be used to run the Rough and the Finishing Mills, eight vertical 40 h.p. motors for the Griffin Mills and twenty-two 40 h.p. motors to drive the Ball Mill.

* * *

The Hudson Companies have ordered the following Electrical equipment for the twin tubes under the Hudson River connecting New York with Jersey City, viz:

Two ATB 4–3000–750–1100 volt Curtis steam turbine-generators.

Two ATB 4–6000–750–11000 volt Curtis steam turbine-generators.

Two ATB 4–6000–750–1100 volt Curtis steam turbine-generators.

One hundred GE–76 motors.

Fifty multiple unit control equipments.

Eleven HC 12–1500–250–525 volt rotary converters.

Thirty-six AB 25–550–9500/9750/10000/10250–10500–450 volt transformers.

The turbine-generators are to be installed in a power house situated between Jersey City and Newark, and the power transmitted to three substations located, respectively, at Greenwich and Christopher Sts., and Cortlandt and Church Sts., New York City, and Washington and First Sts., Jersey City.

The rolling stock will consist of fifty double motor cars equipped with GE 69–160 h.p. motors.

* * *

Ten four-motor GE 100–1200/600 car equipments with Sprague General Electric Type M Control, together with 10 emergency straight air brake equipments, have been ordered by the Indianapolis and Louisville Traction Co. of Indianapolis, Ind. These will be used in a new line forming the link which completes a long interurban railway from Indianapolis to Louisville.

One of the interesting facts in this connection is that this is the second 1200 volt D.C. trolley to be installed.

Part of the way the cars are to run over the tracks of a 600 volt interurban trolley road; it is therefore necessary that the equipment shall operate at full speed on either 600 or 1200 volt trolley. The motors are therefore designed to run two in series for 1200 volts, or four in multiple for 600 volts; and to insure satisfactory operation when the two motors are in series on the twelve hundred volt trolley, it was necessary to design each motor to withstand 1200 volts across the armature; such condition being met with in event of one pair of wheels slipping.

The line is 106 miles long, 41 miles of which will be of 1200 volt operation, fifty miles of 600 volt trolley on the Indianapolis end, and 15 miles of 600 volt operation on the Louisville end. The 41 miles of 1200 volt trolley will begin at Seymour, Ind., and extend to Sellersburg, Ind., and will be fed from a generator station near the middle of the line. By adopting 1200 volts for the trolley, the expense of a transmission line and substations is saved.

The Edison Illuminating Co. of Detroit, Mich., have been operating General Electric 3000 kw. Curtis turbine-generators in their old plant, and have found the machines so satisfactory that they have decided to equip their new plant with similar apparatus, and to this end have ordered, as a first installment, one ATB 10–8000–720–4600 volt Curtis steam turbine-generator.

The new installation will eventually have five or six of these machines, each of 8000 kw. capacity.

* * *

The Lisbon Electric-Tramways, Lisbon, Portugal, have just placed orders with the General Electric Company for five, two-motor, and twenty, four-motor GE–59, 35 h.p. equipments. All the car outfits on this line have been furnished by the General Electric Company and have the same type of motor. The present order will raise the number in operation to 145 double and 20 quadruple equipments.

On account of the exceptionally narrow streets, the gauge of track used is 90 centimeters, (about 35.5 in.) And the GE–59 motor is a modified form of the GE–58 shortened sufficiently to take the diminished gauge.

The entire electric equipment for the Lisbon Tramways was furnished by the General Electric Company about 6 years ago.

* * *

The Foreign Department of the General Electric Company has received the following order for apparatus to be used in a further extension of the Cauvery Plant.

One ATB 10–1500–3000–2200 volt generator.

One 6–110– h.p.–500–2200 volt motor.

One MP 6–75–465–110/1125 volt generator.

One generator exciter set consisting of an MP 6–75–465–110 volt generator connected to an I 6–110–500–2200 volt motor.

Since its original installation in 1900, when an aggregate of 4320 kw. of generating capacity, in six units of 720 kw. each, was put in, two important additions to the generating equipment have been made. After two years of operation the demand for power was found to be so large that the original plant was practically doubled, and an additional installation of five 720 kw. units, together with transformer and switchboard equipment, was purchased, and now a third installation is to be put in.

As is well known, this plant, which was the pioneer and has remained the largest and most important high voltage power development in India, has proved a marked success in every respect and has continued from the start to earn a profitable return on the investment. The entire plant and transmission system are a government enterprise under the control of His Highness the Maharajah of Mysore, the bulk of the power being used in the Koler Gold Fields at a distance of 100 miles, and for the street railways and lighting in the City of Bangalore.

All the electrical apparatus of the Cauvery Plant was furnished by the General Electric Co.

* * *

The report has been received from Boston of eighteen orders for small motors, the total number of machines being 870 and amounting to 2589 h.p.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

A Single-Phase Builder's Hoist

[Elec. Wld., Nov. 3, 1906, p. 889]

A description of a portable builder's hoist made by the Trucksal-Painter Mfg. Co., of Chattanooga, Tenn. This hoist, an illustration of which is given, is mounted on a heavy truck, is equipped with 3 h. p. General Electric single-phase motors with double reduction gearing, and has a lifting capacity of 500 lb. at a speed of 250 ft. per min. Reversing is obtained by means of clutches which allow a continuous rotation of the driving motor in one direction, and which can be operated while the hoist is working.

Electric Installation in Shipbuilding Shop

[Elec. Wld., Nov. 3, 1906, p. 885]

An illustrated account of the electrical equipment of the Harlan & Hollingsworth Corporation, of Wilmington, Del., which comprises an extensive General Electric switchboard, two 300 kw. 150 rev. per min., 250 volt, three-wire General Electric generators and one three-unit, 2400 rev. per min., 125 volt horizontal type Curtis steam turbine-generator consisting of a steam turbine driving two 75 kw. generators. The generators are used to supply various electric motors, ranging in capacity from 1 h. p. to 140 h. p., of constant speed and variable speed type to satisfy the requirements of the various machines which they drive.

The Pennsylvania Tunnels Across Manhattan Island

[R. R. Gaz., Nov. 2, 1906, p. 380]

The United Engineering & Contracting Co., the contractors for building the tunnels under 32d and 33d Streets, New York, use electricity throughout in the ground plant, and compressed air from electric driven compressors for all operations below ground, except haulage. Several 10 ton General Electric locomotives, each equipped with two 40 h. p. motors, are used, having a drawbar pull of 3500 lb. and a speed of six miles per hour, and operated by double trolley, or by means of an automatic cable reel when the locomotive is run up close to the headings. Direct current is supplied at 230 volts by the New York Edison Co. for operating these locomotives together with three 200 h. p. General Electric motors for belt driven air compressors, one 480 h. p. 100 rev. per min. Fort Wayne motor for a direct driven air compressor, and a number of smaller centrifugal pump and hoist motors. The article is illustrated by views of the machinery and by section drawings of the tunnels.

The Trust Company of America Building

[Eng. Rec., Oct. 20, 1906, p. 442]

An illustrated account of the construction of the foundation of this new twenty-five story building, which is one of the several new structures which have recently been erected to replace buildings of nine or ten stories in height. The mechanical equipment includes six electric elevators, and an electric lighting plant operated by General Electric generators. The article is the first of a series on this building.

INDEX

Page

Building:
  Trust Company of America Building 16
  (See also "Cranes and Hoists")
  Cauvery Plant, India, Equipment of 15

Cement Manufacturers:
  Universal Portland Cement Company 14

Circuit Breakers:
  D.C. Circuit Breakers, Testing of, by F. L. Kemp ... 10

Compressed Air:
  Iron Foundry, Compressed Air in, by C. L. Prince .. 7

Cranes and Hoists:
  Trucksal-Painter Manufacturing Company 16

Foundry, Compressed Air Used in (See "Compressed Air")

Generating Systems:
  Edison Illuminating Company, Detroit 15
  (See also "Traction")

Hanscom, Mr. P. T.
  New Work of Mr. P. T. Hanscom in Central Colorado Power Development 12

Notes 13

Paper Mills:
  Great Northern Paper Company, Millinoket, Me. 14

Regulators, Tirrill:
  Experience with a Tirrill Regulator in the Electricity Works at Wels (Austria) 4

Rolling Mills, (See "Steel Works")

Sales Notes 14

Ships, Electricity Used on:
  Shipboard, Electrical Applications on, by H. W. Hillman 1

Shipbuilding:
  Harlan Hollingsworth Corporation 16

Small Motor Sales 15

Steel Works:
  Indiana Steel Co., Gary, Ind. 14
  Illinois Steel Co., Buffington, Ind. 14
  Carnegie Steel Works, Pittsburg, Pa. 14

Tirrilll Regulator (See Regulators)

Traction:
  Hudson Companies' Equipment 15
  Indianapolis and Louisville Traction Company's Equipment 15
  Lisbon Electric Tramways, Lisbon, Portugal 15
  (See also "Tunnels")

Transmission:
  Cauvrey Plant Equipment 15
  (See also "Traction" and "Hanscom, P. T.")

Tunnels:
  Pennsylvania Tunnels Across Manhattan 16
  (See also "Traction")

Turbines and Turbine Installations:
  Low Pressure Curtis Steam Turbine-Generators 6
  (See also "Generating Systems")

TECHNOLOGY DIVISION

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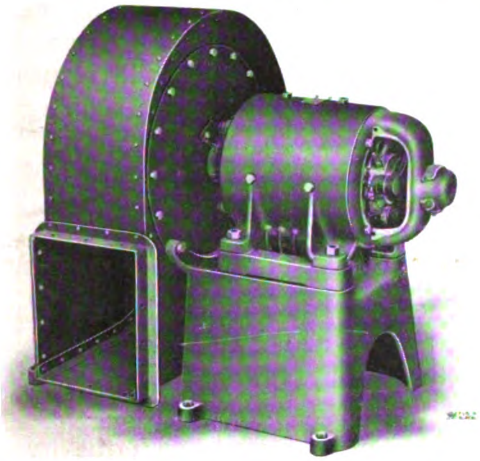
BLOWERS AND EXHAUSTERS

By MAXWELL W. DAY

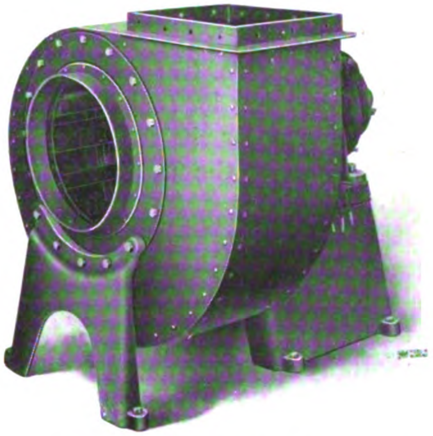


Convertible Steel Plate Ventilation Set

In 1904, after exhaustive tests on various types of fans conducted by Naval Constructor D. W. Taylor at the Washington Navy Yard, the Navy Department adopted new specifications for ventilating sets for use in ships of the Navy. Instead of taking the various standard sizes of fan manufacturers, as has been previously done, the Bureau adopted certain standard sizes rating them according to the number of cubic feet of air delivered per minute as follows:

600
2500
4000
5000
6000
8000
10000
12000

These were to be so designed that the velocity in the discharge pipe, when the fan was delivering its rated volume, should not exceed 2,000 cu. ft. per minute with a static pressure of about 5 lbs. per sq. foot in the discharge pipe. The previous rating of pressure had been in oz. per sq. inch, and the former method of test had been to measure the total pressure of the air when escaping through a conical orifice, the area of which was equal to one-third of the product of the diameter of the wheel by its width. The new specifications require a straight test tube 20 times the diameter of the pipe in length with a double Pitot tube inserted at the center of it, one tube of which read the static pressure and the other the total or impact pressure.



Convertible Steel Plate Ventilation Set

As the weight of air changes with different atmospheric conditions, the test requirements did not call for the 5 lbs. per sq. ft. pressure, but for a height of water column in the measuring gauge equivalent to 13.4 times the weight of air per cubic foot and the impact reading 17.4, equivalent to 5.2 lbs. static pressure at the Pitot tube, or, allowing for the inlet and pipe friction and velocity head, about 8.5 lbs. per sq. ft. total pressure.

The specifications also require that the fans can be readily changed to run in the other direction and to have 16 different directions of discharge, that is, 8 for right hand rotation and 8 for left hand.

It also required that the motors shall have power enough to run the fan wide open without any inlet or outlet pipe. To meet these requirements the Power & Mining Dept. has brought out a line of fans, those of 2500 cu. ft. and above having steel plate casings as shown in the illustrations; the 600 cu. ft. fan having cast shell casing.

The navy fans are all exhausters, that is, they have a single inlet provided with a ring to which a suction pipe can be attached.

The inlet is of such diameter as to give a velocity of 2,000 cu. ft. per minute when the fan is delivering its rated volume, and the outlet, except for the cast shell fan, is rectangular having the same area as the inlet. The diameter of the inlet is three-quarters that of the wheel and all the fans are based on the inlet dimensions, and the outlets are all of the same shape to the nearest 1/8 in. This gives a line of absolute uniformity in appearance, and it naturally follows that the characteristics of the various fans are very nearly the same, though, naturally, the large sizes show a little better efficiency.

The convertible feature is shown in the illustrations. The casing is constructed with a supporting ring on each side, which is bolted to a crescent shaped extension on the motor base on one side, and to an outboard support on the other. By taking out the bolts, the case can be turned to as many different directions as there are bolts, or 16 in each direction for the steel plate sizes, although the specifications only call for 8. This convertible feature is very desirable, as it allows the fan to be made for stock and then can be readily changed by the customer to any desired angle of discharge.

To assemble the fan for the other direction of rotation, it is necessary to take the case off and turn it around, and also disassemble the wheel and reassemble it in the other direction, the construction of the wheel being so arranged that this can be readily done.

As the fans are required to run wide open, it is desirable, in order to avoid the use of a large motor, to so design the fan that the load wide open shall not be much greater than the rated load. It is well known that a centrifugal pump will require considerably more power when running under a low head at constant speed, than under a higher head at the same speed, and particular attention was given in the design of this fan to avoid excessive loads when run wide open.

The wheel is supported by a plate on one side, so as not to obstruct the passage of the air by the spokes generally used in other types.

The motors for use with the navy fan are the CQ for the cast shell fan, and CR for the 5,000 and below, and special MP motors for the larger sizes.

A speed reduction by field control of 20% from the maximum speed is required.

These fans are designed for comparatively high speed, which is obtained partly by the shape of the blades and partly by the relatively small diameter of the wheel as compared with the inlet. In the navy fans, the scroll is fastened on with bolts, so that it may be readily removed to get at the interior, but for ordinary commercial work this would not be necessary.

In addition to these exhausters which are used for hull ventilation, we are also building forced draft fans. These are not connected to any inlet pipe and are, therefore, made with two inlets of suitable form, one on each side, and are designed to give 17,500 cu. ft. of air per minute at a total pressure of 2 in. of water, equal to 10.4 lbs. per sq. ft. These are not convertible and are made of comparatively small dimensions and discharge directly through the deck into the fire-rooms. They are to be opeated by CB motors of about 15 h. p. capacity. The armored cruisers NORTH CAROLINA and MONTANA, scout cruisers CHESTER, BIRMINGHAM and SALEM and the battleships SOUTH CAROLINA and MICHIGAN are being all equipped with General Electric hull ventilation sets, and in addition, the armored cruiser NEW YORK, which is being refitted at the Boston Navy Yard, is to be supplied with them. The forced draft fans now on order are for the SOUTH CAROLINA and MICHIGAN, there being 12 on each ship.

The ships mentioned above will have 112 hull ventilation fans and 24 forced draft fans, or a total of 136.

Several have already been delivered to the testing dept.

These fans are well adapted for general commercial use, such as the ventilation and heating of buildings and the ventilation of transformers, turbine generators and other electrical apparatus. We have already built one fan for ventilating an 800 kw. turbine generator for the East St. Louis & Suburban Ry., two for the 200 kw. turbine generators for the Battleship NEW HAMPSHIRE, and one for a 1000 kw. motor generator set for San Francisco. We are also building five for ventilating the electrical apparatus of locomotives, three for motor generator sets, one for a 1000 kw. turbine generator for East St. Louis & Suburban, and a sample fan for transformer ventilation and one for cooling mercury arc rectifiers.

As a high speed motor is usually smaller than a low speed motor, considerable gain is made in the size of the motor by using double inlet fans, as twice the quantity of air can be taken without increasing the speed. The transformer fan and the forced draft fans are of this type, and we expect during the next year to have a line of this type developed.

For general commercial work, where it is not necessary to reverse the direction of rotation after the fan is built, we would recommend a non-convertible wheel, as it is a little cheaper. This does not allow the fan to be reversed in direction of rotation, but still it allows the case to be turned in any one of the 16 different positions.

Blowers are designated by the letter B and exhausters by E; convertible sets by the letter C, and non-convertible sets by the letter N. The intermediate form with a convertible case and non-convertible wheel, is called semi-convertible and is designated by the letter S.

The fans are rated by the diameter of wheel to the nearest inch rather than by the rated volume, because it is not necessary that all fans should be rated at 2,000 ft. velocity in the inlet and outlet, as good results can be obtained by running the fan at a greater or less velocity.

The convertible 2500 cu. ft. exhauster, which has 20 3/16 in. wheel, is designated EC-20, if arranged as a convertible blower, it would be BC-20, or if arranged with a stationary case and non-convertible wheel, it would be BN-20. Following is a list of the navy standard fans and does not include those already built for commercial purposes.

EC-10	600 cu. ft.	2300	RPM	.4 h.p.
EC-20	2500 cu. ft.	880/1150	RPM	1¾ h.p.
EC-26	4000 cu. ft.	690/ 900	RPM	2½ h.p.
EC-29	5000 cu. ft.	615/ 810	RPM	3¼ h.p.
EC-36	8000 cu. ft.	490/ 645	RPM	5 h.p.
EC-40	10000 cu. ft.	440/ 575	RPM	6½ h.p.
EC-44	12000 cu. ft.	400/ 525	RPM	7½ h.p.

SOME FEATURES OF PARALLEL OPERATION OF ALTERNATING CURRENT GENERATORS

I

By ERNST J. BERG

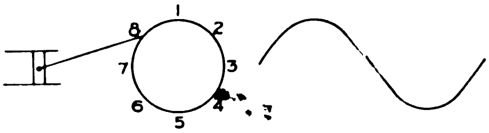
With Alternators running at practically uniform speed and with proper field excitation there is practically no cross current and therefore the current from each machine represents current delivered to the lines. This ideal condition is, however, seldom obtained in practice. With almost every direct connected unit there is a slight pulsation in speed, and with the ordinary adjustment of field rheostats there is usually a slight cross current, although this cross current is not necessarily detected with the station ammeters.

The effect of pulsating speed is to send a cross current between the machines, which substantially represents energy. The effect of wrong excitation is a wattless current and a slight mechanical shift of the two machines in reference to each other. This shift will cause considerable cross current in the neutral of the machine, if these are connected together, and this cross current in the neutral represents energy. So that, it is possible to have energy transfer not only by pulsation in speed, but also by wrong excitation. In addition to this cross current there is a cross current caused by hunting of the machine, which current also represents energy.

Every machine has a natural period of its own, which can be ascertained experimentally by throwing the machine in parallel with a large system when slightly out of phase and noticing the beats while the machine is getting in phase. If this period approaches the beat of the engine, mechanical resonance will take place, which causes a gradual increasing cross current which eventually becomes so large as to make parallel operation impossible.

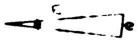
A. Cross current due to pulsation in speed

Let p = total % variation of speed per revolution.



This variation taking place twice per revolution, as seen above. The speed variation is then either ½ p high or ½ p low in a quarter of a revolution so that, the mean variation in a quarter of a revolution is ¼ p.

If the generator has P number of poles, we have then— the displacement of phase of E. M. F. due to the speed variation $= \frac{P \times 180}{4} \times \frac{p}{400} = .112\ P \times p$ degrees.



The cross current is $\frac{e}{Z} = \frac{E \sin(.112\ P \times p)}{Z}$

With $k = \frac{\text{short circuiting current}}{\text{full load current}}\ Z = \frac{1}{k}$

and I = full load current

the pulsating cross is $k \sin(.112\ P \times p)\ I$

Instance, A 40 pole generator with k = 3, maximum speed variation per revolution = .75% = p, what is the cross current?

$I_c = I_x 3_x \sin 3.35° \quad 3 \times .061\ I = .1831.$

This current represents practically energy since it must be in quadrature to the E. M. F., which causes it -e- which again is in quadrature to the main E. M. F.

B. Cross currents due to wrong excitation

Such current is found in the neutral as well as in the mains if similar machines are operated with grounded neutral. In order to determine the magnitude of this current, it is necessary to discuss the general characteristics of alternators, especially in reference to angular displacement of the armatures with load. A theoretical method of obtaining this displacement and the full load excitation is given below.

Let e_0 be the induced E. M. F. per phase. That is the noload E. M. F. corresponding to full load excitation.

e_1 be the E. M. F. corresponding to the terminal voltage and the impedance drop in the armature.

e be the terminal voltage.

F_0 be the M. M. F. on the field corresponding to e_0

F_1 be the M. M. F corresponding to e_1. (from saturation curve)

M be at the ratio of armature reaction to full load current.

$r - jx$ the true impedance of the armature per phase.

$I = i + ji_1$ the armature current

We have then –

$$E_1 = e + (i + ji_1)\ (r - jx) =$$
$$e + ir + i_1x - j\ (i_1r - ix)$$

Let M. M. F. (from saturation curve) correspond to $e + ir + i_1x$ be $= n$ another M. M. F. correspond to $i_1r - ix$ be $= n$ (taken from voltage e. of the saturation curve).

We have then, since the flux is 90° ahead of the E. M. F., the M. M. F. corresponding to $E = jn + n_1 = N$

Thus M. M. F. is the reluctant of the field and the armature M. M. F. We can therefore write –

$$n_1 + jn = jF_0 - m\ (i + ji_1)$$
$$n_1 + jn = jF_0 - mi - mji_1$$
$$jm_1 - n = -F_0 - jmi + mi_1$$
$$F_0 = mi_1 + n - j\ (mi + n_1)$$
$$= \sqrt{m^2\ I^2 + N^2 + 2m\ (in_1 + i_1n)}$$

This gives then the general equation for the full load field excitation for a generator operated with any load at any saturation, no load excitation and armature reaction.

The displacement of the armature with load from the position at no load, is found by equation –

$$\tan \Phi = \frac{mi + n_1}{mi_1 + n}$$

Which shows that in a given machine the displacement depends not only upon the load – that is i – but also, although to a small extent, upon the wattless currents.

This angular displacement of the armature with load is of greatest importance. Assume, for instance, that two machines of different armature reactions and field excitations are to be rigidly connected to the same prime mover, in order that they shall distribute the load correctly at full load, it is necessary to ascertain this angle in each case and to adjust the armatures in reference to the poles an amount corresponding to the difference in angles.

It is obvious that although the machines then will distribute the load correctly at full load, at other loads they may not do so. This same question comes up in arranging frequency changing sets where, say,—25 cycle motors drive 60 cycle generators.

Should therefore two such rigidly connected generators or frequency changers not divide the load properly, the remedy is to shift either the fields or the armatures relative to each other, though, to be sure, a slight improvement can be made by changing the excitation of the two, overexciting one and under-exciting the other, in which case however large cross currents will flow.

In connection with distributing the load between generators operating in parallel from independent prime movers, it is to be remembered that with direct current units the field excitation will decide the load, whereas, with alternating current generators, the field charge has no effect, except in the matter of cross current.

The load can only be changed by changing the power admission of the prime mover. Shortly the speed characteristics of the prime mover determines the distribution of load.

But to return to the cross currents. Since the fundamental wave can not return over the neutral (the sum of the 3 waves is always zero), we can therefore consider the cross currents in the mains quite independently, whether the neutrals are connected together or not.

Since furthermore the mains can have no triple harmonics we can consider the current in the neutral quite independent of that in the mains.

As a matter of fact when considering the current in the neutral we deal with a single phase triple frequency generator built with three circuits in parallel, the three terminals of the windings might be considered as one of the terminals of the single-phase generator, the other terminal being the neutral connection.

1st. Determination of cross currents in the mains

Let e be the no load E. M. F. of one machine.

Let e_1 be the no load E. M. F. of the other.

$r - jx$ be the impedance of the first armature.

$r_1 - jx$ be the impedance of the second armature.

The current flowing after parallel connection is therefore $i_0 = \frac{e - e_1}{r - jx + r_1 - jx_1}$ or neglecting the armature resistance and assuming $x = x_1$ that is similar armatures we get—

$$i_0 = \frac{e - e_1}{2x_0}$$

Substituting this in the equation previously given about angular displacement of armatures for various currents

$$\tan \Phi = \frac{mi + n_1}{mi_1 + n}$$

$$\text{we get } \tan \Phi = \frac{n_1}{m\frac{e - e_1}{2x_0} + n}$$

Instance. Armature reaction = R = **m** I or $m = \frac{R}{I}$ where I is full load current.

$n = 3\ R \quad , \quad e = 1$

$n_1 = .3\ R \quad , \quad e_1 = .9$

$I = 1 \quad , \quad x_0 = 35$

$i_0 = \frac{.1}{.7} = .143$ or cross current in the main is 1.43%. and the displacement

$$\tan \Phi = \frac{.3\ R}{.143R + 3R} = .095 \quad \text{or } \Phi = 5° \ 30'$$

2nd. Cross current in the neutral

The cross current due to the slight difference in voltage is so small that it can be neglected, but the cross current due to the displacement is quite large and must be essentially an energy current as discussed when dealing with cross currents due to variation of angular position.

We found then that this current is very closely expressed as

$$I = \frac{e \sin \Phi}{Z}$$

In reference to the triple harmonic Φ as previously calculated represents here 1-3 of its value for obvious reasons. The impedance Z is 3 times as large as the main impedance on account of the higher frequency, but only 1/3 of that value since the three phases are in parallel, thus $Z = X_0$ – neglecting the resistance. If the ratio of triple harmonic to fundamental voltage is p_0 we have then –

$$I = \frac{p_0 e \sin 3\Phi}{x_0}, \qquad \text{assuming } p_0 = .3$$

we get then –

$$I = \frac{.3 \sin 16° \ 30'}{.35} = \frac{.3 \times .285}{.35} = .245$$

or the triple harmonic is 24.5% of full load current.

We see thus that whereas an ammeter in the mains would only read 14.3% of full load current, an ammeter in the neutral would read 24.5%.

In other words, an ammeter in the neutral is very sensative for detecting error in field excitation. Furthermore it is interesting to note that this current represents substantially .245 x .3 = .073 watts corresponding to a full load output of 1 x 1 x

$\sqrt{3} = 1.73$ or 4.3%. of the output. Therefore 10% difference in excitation meant a transfer through the triple harmonic of 4.3% of energy.

Synchronizing Force

The synchronizing force might be stated as the torque per degree displacement of the armature.

In discussing the compounding phenomenon the equation for angular displacement with load was also given as

$$\tan \Phi = \frac{mi + n_1}{mi_1 + n}$$

At full non-inductive load these become:

$$\tan \Phi = \frac{mi + n_1}{n}$$

Where mi is the armature reaction
n_1 is usually very small and
n very nearly the no load exciation

As a fair approximation we can therefore write –

$$\tan \Phi = \frac{\text{arm. react.}}{\text{no load AT}}$$

At full load the torque at 1 ft. radius in lbs. is $\frac{7050 \text{ Kw.}}{\text{R. P. M.}}$ therefore the synchronous force is $\frac{7050 \text{ Kw.}}{\text{R. P. M.} \times \Phi}$

It is evident from the above that for a given relation between no load AT and armature reaction the definite pole machine has something like twice as great synchronizing force, and in general the better regulation the greater synchronizing force.

Hunting of Alternators

Several years ago Mr. Boucherot published a formula giving the relation between the time of natural beat of an alternator, its rating moment of inertia and percentage short circuiting current of full load current, which is as follows:

$$T = .31\, N \sqrt{\frac{M R^2}{\text{f. A. K.}}}$$

Where

N = Rev. per min.
$M R^2$ = moment of inertia of all moving parts.
k = % short circulated current at no load excitation.
T = natural period of alternator in seconds.
A = Output of alternator in watts.
f = frequency of alternator.
N = Rev. per min. of alternator.
f_0 = natural frequency of pulsation per min. $= \frac{60}{T}$

It would seem very easy, in view of this formula, to choose such moment of inertia that the natural period of the machine would not correspond to that of the prime mover. But unfortunately, this formula is not equally applicable to different types of machines. It is obvious since the angular displacement of the armature in relation to the field for a given output and ratio of short circuiting current to full load current is not the same, but depends also upon the arrangement of the field structure, that in some machines the displacement is almost twice as great as in others, therefore, considerable discretion has to be used.

Since, however, hunting of alternators means transfer of energy as shown in connection with the discussion of effect of angular variation in speed, the phenomena can be largely checked by arranging the steam admission of the prime mover in such a way that it cannot pulsate. This is done by properly adjusting the dash pots of the governor.

It is finally evident that since with definite poles and particularly with small airgap, the self induction changes considerably with the different positions of the armature in reference to the field, that excessive hunting cannot well take place, since the natural position changes.

Complete resonance can only take place when the angular displacement is proportional to the load, which condition is fulfilled in this type of machine only over a small range of loads.

In general we should therefore expect more trouble with round rotor machines than with machines with definite poles,

MANUFACTURE OF HEATING APPARATUS AT LYNN

By D. B. GAUCHET, Superintendent of Production, Lynn Works

The development of heating apparatus started the latter part of the year 1903 in a comparatively small way, and it would appear from the phenomenal growth that the present business was not, nor could not have been anticipated. As a matter of fact, it has grown to such a remarkable extent in the past two years that it is well worthy of mention, having developed into one of the leading departments at Lynn, representing hundreds of people employed, and requiring men of unusual experience, both electrically and technically, to supervise, and necessitating a good business organization with systematic methods, to satisfactorily handle the constantly increasing business.

Testing G. E. Heating Apparatus

The manufacture is handled along well defined lines with stipulated weekly rates on each device, which requires special attention. These rates have had to be constantly increased each quarter for the past two years to meet the demands. Our District Offices have recently scheduled large quantities for weekly shipments. As an example, the Chicago Office is now scheduling 1000 flat irons per week for their district.

The devices manufactured at Lynn include all those using the so-called "Cartridge Unit", and make an ideal line from a production standpoint. These heating units are made by winding a flat ribbon of exact dimensions upon hardened steel arbors, which are then put through the insulating process; after which the coil is placed in its shell with the proper mica insulations and given a severe test before it is allowed to be assembled in the completed apparatus.

Orders received from the first of the fiscal year to the 1st of Nov. amounted to approximately 95,000 units, and our manufacturing orders are so extensive, and accumulation of orders at the present time is so great, that we are forced to do much over-time work in the endeavor to meet the Commercial Department's requirements and accumulate stock in anticipation of the winter and spring business. Plans are being made, however, for a greater output to take care of the rapidly increasing demands.

Assembling G. E. Flat Irons

Flat Irons:

This is one of our most popular devices and our production is now about 5,000 per week with every prospect of a steady increase. The irons are made in three sizes; 3, 6, and 8 lbs. and other sizes are now under development.

Luminous Radiators:

These have come to the front as very popular devices. We are at present putting through 2,000 and the factory, at the moment, is not in a position to produce them fast enough, though this will shortly be remedied.

Glue Pots:

The designing engineers have recently developed additional sizes of glue pots so that we now have a complete line for both 220 and 110 volt circuits. We are also able to build some of the sizes in two heats, which permits of the glue being melted very quickly at a high heat and kept at a constant temperature at low heat. Furthermore, these glue pots will be brightly polished on the inside as well as the outside, making an improvement in appearance which should be appreciated by the salesmen and customers. One thousand or more of these pots are in use and are giving great satisfaction.

Stateroom Heaters:

This heater is a comparatively new device, for which there seems to be a large field. We have recently received orders from an important Steamship Co. for a sufficient number to equip three of their largest vessels. Many of the other Steamship Lines are considering propositions for these heaters, and it is anticipated that extensive orders will be received in the near future.

Miscellaneous Devices:

We are manufacturing, in no small way, ovens, broilers, grids, disc stoves, etc., and the demands for these is steadily increasing. We have produced to date (November 1st) this year, 9,000 of these devices.

The foregoing indicates quite clearly the phenoninal growth of the business and illustrates forcibly what can be done with proper organization in introducing new lines of apparatus. Our engineers and the shop are constantly at work making modifications and improvements upon our present devices, and also reducing the cost by adopting new methods, and, further, have several devices in the process of development which will be ready for the market later.

Inspecting and Packing of G. E. Flat Irons

METHOD OF HANDLING AND STORING TRANSFORMER OIL

By B. E. Semple

A system of handling and storing transformer oil has lately been installed and put into operation at the General Electric Companies' Chicago Warehouse, which provides a clean, convenient and satisfactory method of handling a liquid upon which so much depends after being placed in a transformer or oil switch.

The oil from the refinery, is received at Chicago in tanks containing approximately fifty gallons each, a considerable quantity always being kept on hand to be used in filling orders and for use with shipments of transformers, oil switches, compensators and such other devices as require its use. As a rule, shipments of transformer oil from Chicago, vary considerable in amount and range from one pint to fifty gallons or more.

To provide a means for drawing the required amounts of oil for shipments, when orders are for something less than a complete tank containing fifty gallons, an eleven hundred gallon steel tank, measuring 137 inches in length and 48 inches in diameter inside, has been buried 18 inches below the surface of the private driveway on the south side of the warehouse and adjoining the south foundation, the tank being surrounded by dry sand.

On the top of the tank at one end, a water tight manhole is provided through which a person may enter, when it is necessary, for the purpose of cleaning. A pipe enters on this same end and continues almost to the bottom, at the same time extending up to the surface of the driveway, its exposed end being protected and covered by an iron box with a removable lid. This pipe is used as a filler for conveying the oil from the fifty gallon tanks to the large tank beneath the surface; it contains a strainer of fine mesh which serves to catch any foreign substance that might otherwise enter. This strainer is made and installed in the pipe in such a manner that it can be easily removed and cleaned.

On the other end of the tank another pipe enters at the top and extends to the bottom, and is also carried through the foundation of the warehouse to a pump located inside the building in the basement and which is used for drawing the oil from the tank. A small copper pipe enters the top of the tank on this same end, extending just far enough into the tank to be visible from the inside but not touching the oil, this pipe is also carried through the foundation to the inside of the building and connects with a chamber containing chemicals to absorb any moisture that might collect in the tank.

The tank itself, together with all fittings and pipes, with the exception of the copper one, are heavily galvanized both inside and out to prevent rusting, as this would readily decrease the insulating qualities of the oil.

A fire proof cabinet 21¾ in. deep, by 35½ in. wide and 67 in. high having two swinging doors, which can be tightly closed and locked when not in use, surrounds the pump in the building. This cabinet also contains the chamber that holds the drying chemicals.

The pump is of the piston type, the piston being moved by a crank operated by hand, one complete turn of the crank drawing 2½ gallons of oil. A graduating device is also provided so that either one gallon, one-half gallon, or one quart may be drawn by the full movement of the crank. It is further equipped with a discharge registering device indicating in gallons up to 5000 and repeating. In addition to these, a gallon meter is attached to the pump and can be referred to by the person drawing oil in case the count is forgotten.

The pump measures positivel quantities —thereby doing away with measures and funnels,—and is equipped with an anti-drip nozzle arranged to cut off the flow of oil when the pumping ceases, thus allowing practically no dripping.

To operate the pump, a can is hung on the nozzle; the indicator, showing the various quantities the pump is capable of drawing at one stroke, is set at the amount to be drawn; the crank is next turned as far as it will go and then reversed; it will then have measured directly into the can the correct quantity of oil.

The pump is provided with a locking device so that it cannot be operated without a key, the device being entirely out of the way when the pump is in use.

The entire outfit is so constructed as to prevent evaporation and complies with the most rigid Insurance rules.

Additional Notes

In installing a tank for the storage of oil, which is to be used for insulating purposes, care should be taken to have the tank slope slightly, making one end lower than the other, and the pipe through which the oil is drawn off should extend as near as possible to the bottom of this low end. In this way any moisture that might collect will be drawn off and not allowed to accumulate.

At the Schenectady Works, the tanks are not galvanized as in the Chicago plant, but are made of boiler plate, which is thoroughly scraped to remove scale, and after having been washed with benzine, is given two coats of shellac, which prevents corrosion and also binds fast any small particles of scale that were not removed by the scraping.

To make certain that the insulating proprieties of the oil are up to the standard, samples are drawn from the bottom of the tank every four weeks and tested for break down by means of a small testing set designed for this purpose.

The electrodes used in this test are disks one half inch in diameter separated two tenths of an inch.

At the present writing, the samples of the oil which is in storage at Chicago are tested in Schenectady, but this is merely a temporary arrangement pending the installation of a test set in Chicago, which set will shortly be placed in operation.

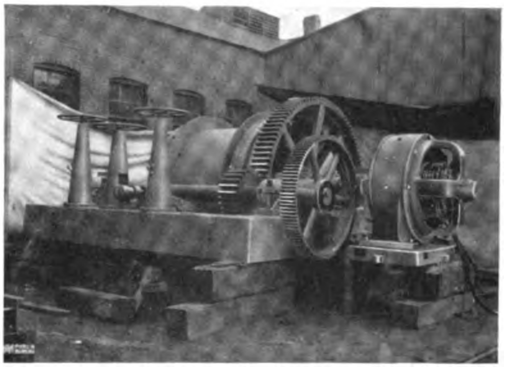
ELECTRIC HOISTS FOR MINING

By LEONARD WILSON, Denver, Col.

The use of electrically operated hoists in the Colorado and Utah Mining Districts is rapidly increasing, and the Mine Engineers express great satisfaction with the performances of the electric hoists already installed.

The Denver Office Sales Record shows that 25 hoist motors, with an aggregate of 550 h. p. have been sold in this territory during the month of October.

One of the largest electrically operated hoists that has been made for this district, has recently been installed at one of the Victor Fuel Company's mines. This hoist, built by the Denver Engineering Works, is an exceptionally fine piece of work. It is designed for underground haulage, and will be used at once to draw a trip of fifteen loaded cars up a maximum grade of 8%. It is intended to add to the motor equipments at a later date and increase the duty to 25 loaded cars. The hoist has a drum six feet six inches in diameter, and is designed for a rope pull of 20,000 lbs. and a rope speed of 400 feet per minute. The hoist is equipped with two brakes, each controlled by a hand wheel, and has one standard Denver Engineering Works improved friction clutch, which is also controlled by a hand wheel.



Electrically Driven Mine Hoist

The electric equipment of this hoist consists of one CLC 6-150-500-250 volt compound wound commutating pole motor, controlled by a master control system, which system will permit the additional of another 150 h. p. motor when the duty of the hoist is increased. The total weight of this hoist and motor is about 75,000 lbs. It is undoubtedly the largest electric hoist employed in mining work in the West.

THE ELECTRIFICATION OF THE WEST JERSEY AND SEA SHORE RAILROAD

By JOHN R. HEWETT

Now that the electrification of the West Jersey and Seashore Railroad has been completed, it is an appropriate time to consider some of the important features of this undertaking, making special note of those which are likely to affect similar installations in the future. It is advisable first to give a description of the work under consideration; which description will be made as brief as possible owing to the length of the recently published articles in the technical press.

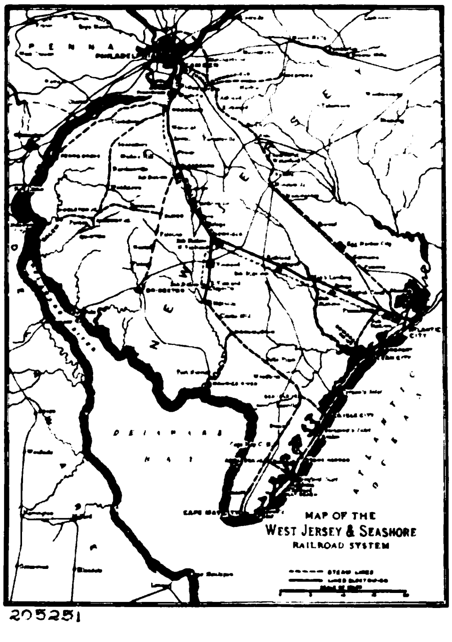


Fig. 1 Map of the West Jersey & Seashore Railroad System

The map above shows the route electrified and also the shorter route of the Pennsylvania system connecting Camden with Atlantic City. The location of the power house and sub-stations, and also the course of the high tension transmission line are given on the same map.

The general scheme of electrification may be briefly summarized as follows:

A. C. current is generated in the power house at Westville, N. J., at a pressure of 6600 volts: the machinery used for this purpose consists of three 2,000 kw. Curtis steam turbines supplied with steam at a pressure of 175 lbs. per square inch from 12 Stirling water tube boilers, each of which are rated at 358 h. p. The current is stepped up from 6600 to 33000 volts at the power house and is fed at the latter pressure to the high tension transmission line.

The transmission line, which is 71 miles in length, is in duplicate throughout, and consists of six No. 1 B&S hard drawn copper wires mounted on porcelain insulators. The system is "Y" connected and has its neutrals grounded.

The six wires of the transmission line are arranged to form two inverted equilateral triangles. This disposition of the wires gives four wires on the top cross arm and only two on the bottom and was adopted in order to facilitate the work of the linemen in permitting them to climb the poles and work on a dead circuit without fear of contact with the live wires. The wires are farther away from the poles than would have been possible if the triangles had not been inverted.

The sub-stations supplied by this transmission line are eight in number, all of which are equipped with rotary converters of sufficient capacity for the section of the road they supply. In these sub-stations the voltage is stepped down from 33000 to 430 volts before being fed to the rotary converters, the D. C. voltage of which is 650. The equipment of these sub-stations will be dealt with in greater detail hereafter.

The road from Camden to Atlantic City is equipped with a third rail, with the exception of the 4.4 miles of track between Haddon Avenue and South Gloucester; here the road passes through the city streets at grade, and an overhead trolley has been installed. On the single track road from Newfield to Millville, the overhead trolley has also been adopted.

The work of electrification has attracted a considerable amount of attention, no doubt on account of the magnitude of the undertaking; and also, as was only natural when remembering the trend of modern engineering, there was considerable discussion as to whether AC or DC motors should be employed, but after all, the most interesting feature in the work was the short time in which it was accomplished.

As regards the magnitude of the work it is sufficient to state that the terminals at Camden and Atlantic City are 65 miles apart, and the road is double tracked throughout, with three tracks extending from Camden to Woodbury, and in addition to the electrification of this road, the track between Newfield and Millville has been equipped for electrical operation. Again, when considering the time in which the work was carried out it must be borne in mind that besides the building of the power house and eight sub-stations already referred to, there was 71 miles of high tension transmission lines to be constructed, the equivalent of 150 miles of single track to be bonded and installed with a third rail, the building and equipment of two new terminal stations and the building and equipment of 68 motor cars furnished with multiple unit apparatus. The contract for this work was only signed on Feb. 16, 1906, and on Sunday, July 1st, two boilers were under steam, a turbine running, the sub-station in the power house was in operation, and the first train to take current from the power house was run. Such a performance has established an engineering record not likely to be easily passed in the future.

The rapidity with which the work was done, and the quality of the work, were largely influenced by the system adopted of cultivating the interest and co-operation of the contractors, foremen and workmen. Every man was made to feel that the ultimate results depended on his work and energy, and each individual in charge of any piece of work was given a full measure of responsibility and credit.

Referring again to the choice of AC or DC apparatus for this particular work, it can be stated without fear of contradiction that the service requirements could have been met had either type been chosen, and, as a matter of fact, propositions for both descriptions of apparatus were prepared. As it is now generally known, DC motors were installed, and the prime factor in determining their selection was the time in which the apparatus could be manufactured rather than any inherent characteristic possessed by either type of motor.

As previously stated, the Pennsylvania Railroad Company has two lines connecting Camden with Atlantic City, and it is the longer of these that has been chosen for electrification. The steam service on the shorter road consists chiefly of express trains stopping at few intervening points between terminals, while that on the Newfield branch comprised a local traffic, in addition to the through express service. It was the difference in the nature of the traffic on the two roads that determined the choice of the longer route for electrification, as the local traffic could be handled much more economically and expeditiously by electric traction than was possible by steam service. There is also a considerable amount of freight traffic on the New field branch.

While touching on the subject of traffic handing, it is of peculiar interest to note the different methods of handling the trains on the West Jersey & Seashore road before and after electrification. Formerly, steam trains consisting of 12 to 15 cars were run at intervals varying from one to three hours, while under the present system, electric trains composed of one, two or three cars will be run at intervals of from ten to thirty minutes.

motorman and conductor for each train so formed, to make it a complete operating unit; while with steam practice, a locomotive and train crew must be kept waiting at each point where such a division of trains is required.

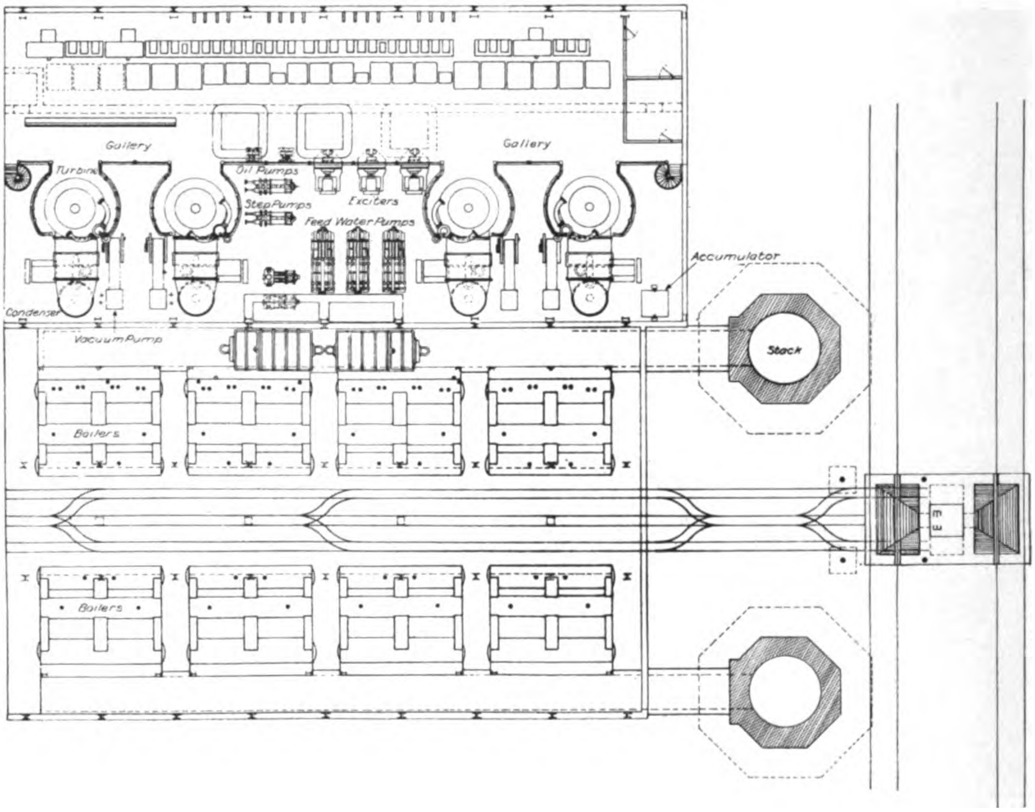


Fig. 2 Plan of Westville Power Station

The facilities for handling the traffic on the West Jersey and Seashore Railroad are greatly increased by the fact that the cars are all equipped with multiple unit apparatus, which enables any car to be operated singly or in a train of several cars, and this system further permits a train being split up into sections when a branch road is reached, or if the train as a whole is not required to run the entire distance. In this manner one train can be split into two or more units, only needing an additional

The power house is located at Westville, N. J., which is only 5.5 miles from the Camden Terminal. This site was chosen, not on account of its location relative to the line, but owing to the fact that it was the only place where sufficient water of a quality suitable for boiler feed and condensing purposes was available.

In equipping the power house every effort was made to use standard apparatus only, and the design and lay out of the building was carried out with a view of its being looked upon as standard for such work in the future. It is a matter of great importance that such things should be standardized as nearly as possibly, and also that every improvement in the general arrangement of apparatus, etc., be incorporated in such standard plans. Usually no radical changes are necessary in the arrangement of power house machinery, and it is to be hoped that in the future, a general system will be adhered to excepting when local conditions demand changes. The plan and sectional elevation of the Westville Power House are shown in Figs 2 and 3.

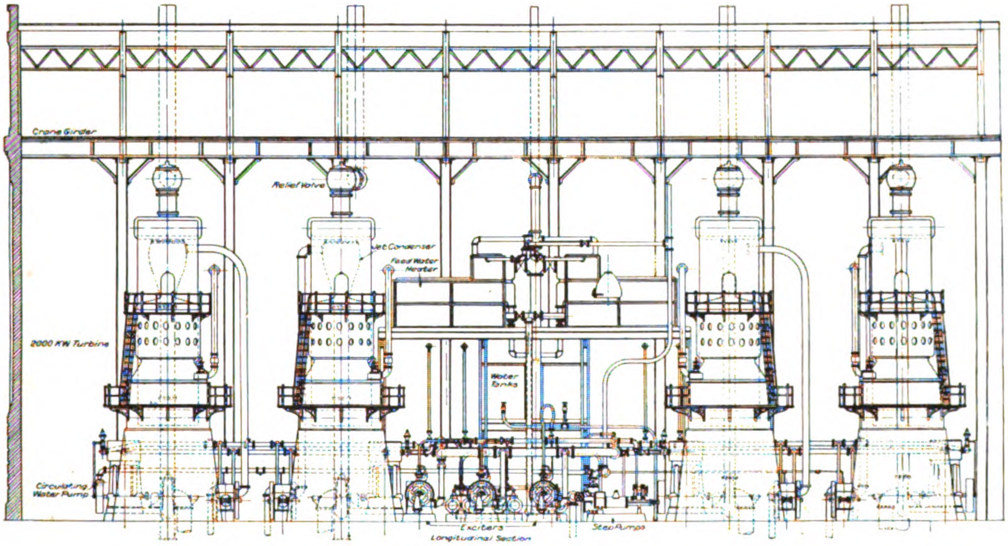


Fig. 3 Longitudinal Section Through Turbine Room of Westville Power Station

Another matter worthy of careful consideration, is the basis it is best to select for the first cost of power house. This point should be determined from the stand point of its ultimate effect on the cost of producing power; there is no advantage to be gained by increasing the primary cost beyond the point where the increase in invested capital effects a gain in economy of operation.

Most of the foregoing remarks regarding the standardization of power house plant and arrangement of apparatus are applicable to sub-stations, perhaps even in a more marked degree, as a standard arrangement for sub-station apparatus is a more simple matter.

The sub-stations on the West Jersey and Sea Shore road can be taken as representatives of the best engineering practice for this class of work, The plan of the sub-stations is given in figure 4. The most interesting data concerning all the sub-stations is given in a condensed form in the table at the end of this article.

The kw. capacity per square and cubic foot enables a very useful comparison being made with other sub-stations and is also a ready method of determining, relatively, the comparative cost of construction.

On such systems of electrification as the West Jersey & Sea Shore road, the point which is more pre-eminently important than all others, is the reliability of the system as a whole, and its capability of keeping the road in operation continuously under all conditions. Reliability of operation should be secured at all costs, even if it involves the installation of special or additional apparatus. Other points worthy of note on the electrification of the West Jersey and Sea Shore Railroad are the arrangements made for protection from lightning, the form of third rail jumper used, the method of installing the third rail insulators, the sectionalization of the third rail and the electrical equipment of the terminal stations. These will be dealt with in the order given above.

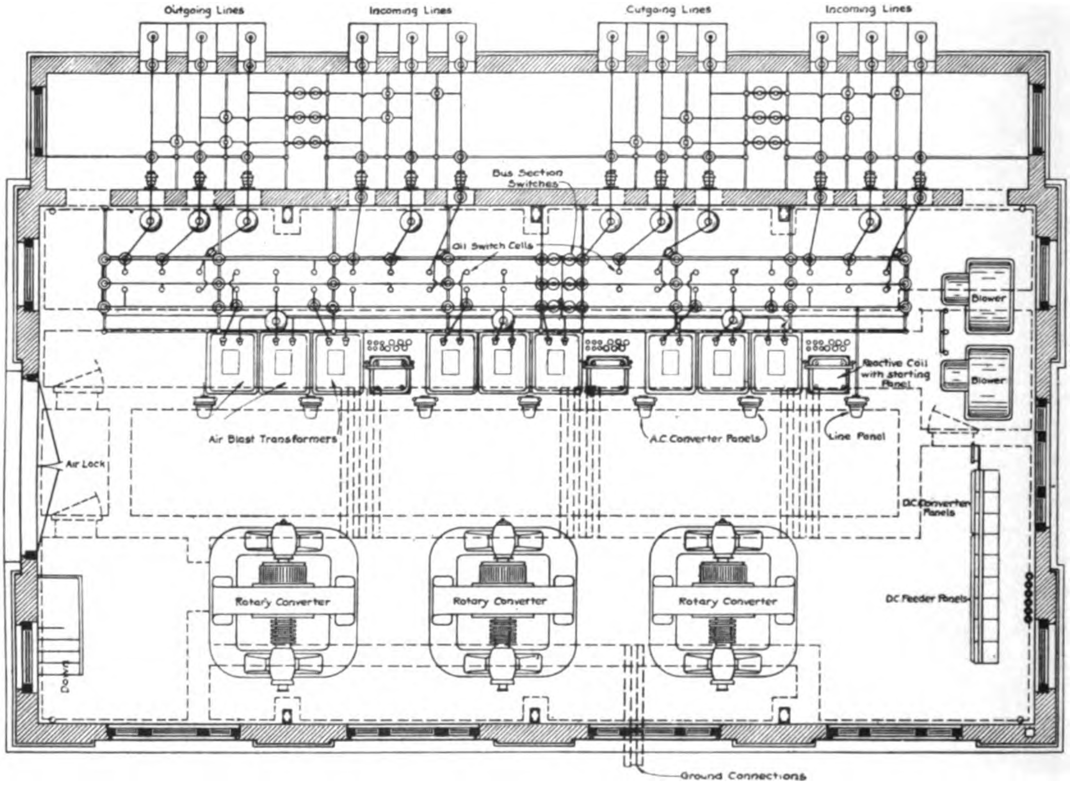

Outgoing Lines
Incoming Lines
Outgoing Lines
Incoming Lines
Bus Section Switches
Oil Switch Cells
Blower
Blower
Reactive Coil with starting Panel
Air Blast Transformers
A.C. Converter Panels
Line Panel
Air Lock
DC Converter Panels
Rotary Converter
Rotary Converter
Rotary Converter
DC Feeder Panels
Down
Ground Connections

Fig. 4 Plan of Typical Sub-Station

The best method of protecting the entire system from lightning was given a great deal of careful consideration, and that finally adopted is believed to be as reliable as any that it is possible to obtain with our present scientific knowledge.

The transmission line is protected by means of a seven strand galvanized iron cable, 3/8 of an inch in diameter, which is strung for the entire length of the line on top of the transmission poles. It is situated about 4 ft. above the nearest active wire and is provided with a ground at every fifth pole. It is anticipated that this arrangement will form an efficient supplementary adjunct to the lightning arresters.

The lightning arresters in the power house and all sub-stations are of the GE multiplex type, and these, together with the choke coils which are connected in series with each of the incoming lines, and the cutout switches, are installed in a chamber separate from the rest of the building. This method of installing the lightning arresters and cutout switches in separate chambers, reduces the risk of fire in the power house and sub-stations to a minimum.

The third rail jumpers are of a specially neat design and are illustrated in Fig. 5 which shows their form of construction. As will be seen, the cables are drawn into a black bitumenized fibre tube which is encased in a solid block of concrete, making an excellent insulating protection for the jumper. The top of the jumpers, the point at which the cables enter the tube, are protected by means of terra cotta covers.

This form of jumper is installed at all places where a continuous third rail is impracticable, and is both better and more efficient than any type which has hitherto been used.

The third rail insulators are made of reconstructed granite and are interesting as concerning the method adopted for securing their position on the ties. This can be seen by reference to the left hand portion of Fig. 5. A malleable iron centering cup is secured to the tie by means of a single lag screw, and the insulators are provided with a hole in their underside to enable them to slip loosely over the cup. The advantage derived by adopting this method is that no tension strain is brought to bear on the insulators, due to the depression of the tie when a train passes: and it further simplifies the installation and replacement of the insulators, as, in the first case, the insulators only need placing over the centering cup after these have been screwed to the tie, and in the second case, the only necessary work is to prize up the rail and slip the insulators in position.

To obtain the combined conductively of the two third rails, they are connected electrically, but at the same time, provisions are made to insure only a short piece of single track becoming dead in the event of an accident. These desirable results, securing the collective conductively and sectionalization of the third rail, are obtained by the insertion of a combined switch and fuse box at points midway between each sub-station, the gaps in the third rails at these points, being filled with pieces of wood flush with the surface of the rail.

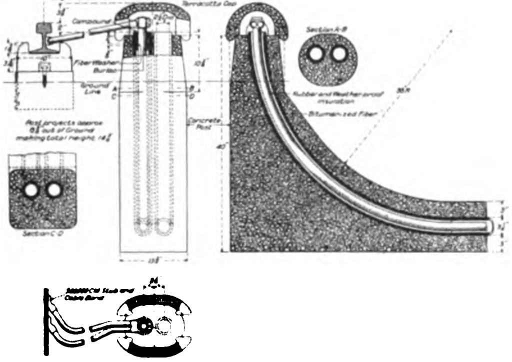


Fig. 5 Third-Rail Insulation and Jumper

The sketch shown in Fig. 6 will give a clear idea of the electrical connections and arrangement of switches and fuses. The sections of rail marked A and B with the gap between them, represent one third rail, and C and D the other. When a short circuit occurs on any one section, the circuit breaker will be thrown in the nearest sub-station, and the fuse electrically nearest that section of the rail, will be blown out owing to the rush of current.

The following will show the conditions for a short on each section.

Short on A blows fuse No. 1,—fuse No. 1 takes total current from all sub-stations, while 2, 3 and 4 each take one third.

Short on B blows fuse No. 4, fuse No. 4 takes total current from all sub-stations, while 1, 2 and 3 each take one third.

Short on C blows fuse No. 2, fuse No. 2 takes total current from all sub-stations, while 1, 3 and 4 each take one third.

Short on D blows fuse No. 3, fuse No. 3 taking total current from all sub-stations, while 1, 2 and 4 each take one third.

From the above it is apparent that a short on any section of the third rail, will incapacitate that section alone, and that it will again be operative immediately the circuit breaker in the sub-station is closed, although it will draw no current from the other sections until its fuse has been replaced.

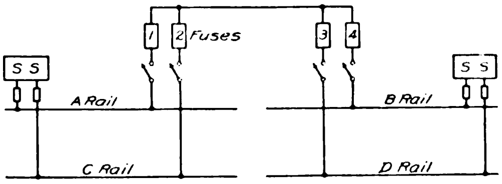


Fig. 6 Diagram Showing Connections, Arrangement of Switches and Fuses Between Sections of Third Rail

The combined switch and fuse boxes are located between the two tracks and each contains four switches and four fuses.

Both terminal stations, which consist of a number of stub end tracks with platforms between, have been equipped with third rails rather than adopting any form of overhead current collecting device. This is of special interest, as this system was adopted on the score of its being more simple to construct and operate than any system of overhead trolley; and, as is well known to most engineers, the concensus of opinion hitherto has been opposed to these views. The operation of these terminals will be watched with much interest.

In conclusion, it may be remarked, that a comparison of the operating expenses of the West Jersey and Seashore road, giving figures for the old steam and new electric service, will be of great value if they can be secured after the road has been in operation for some time, and such figures will surely have great weight in influencing the judgment of many steam road managers contemplating electrification.

ROTARY CONVERTORS

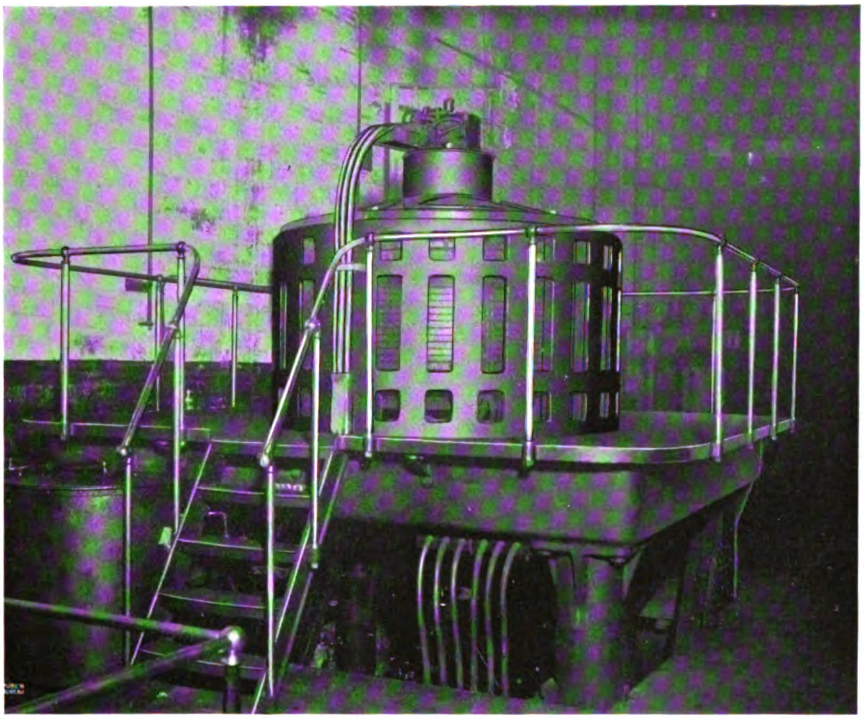
SUB-STATIONS	Kw Capacity already installed	Ultimate kw. Capacity	Square feet per kw. (Ultimate Capacity)	Cubic feet per kw. (Ultimate Capacity)
South Camden	2–750 units	2500	.97	20.4
Westville (in Power House)	2–750 "	2250	Included in Power House	Included in Power House
Glassboro	2–750 "	2500	.97	20.4
Newfield	2–750 "	2500	1.24	26.0
Clayville	* 2–500 "	2500	.97	20.4
Mizpah	* 2–500 "	2500	.97	20.4
Reega	2–750 "	2500	.97	20.4
Atlantic City	2–750 "	3500	.96	20.4

*The 500 kw machines are temporary, 750 kw units to be installed

MOTOR DRIVEN ROTARY PUMP

This set consists of a 1500 h. p. induction motor running at a speed of about 495 RPM, direct connected to a Worthington volute pump. The rating of the motor is I-6-1500-500, Form LM, 2200 volts. Full load current is 325 amperes at an efficiency of 94.6% and a power factor of 95.1%. The motor is type LM, that is, smooth starting is obtained by the insertion of resistance in the circuits of the rotor. This resistance is short circuited when full speed is reached, so that under load, the motor operates as a form K, that is, with the highest possible efficiency. The set is of the vertical shaft type with the motor above the pump. In addition to the two guide bearings, there is in the upper bearing bracket a step bearing which carries the weight of the revolving parts. This step bearing consists of two plates, between which oil is forced; thus a film of oil carries the entire revolving weight. Forced lubrication is used also for the guide bearings.

This motor displaced two large reciprocating plunger pumps, each driven by a 1500 h. p. engine, and is able to deliver more water than these two engines combined.



Motor Driven Rotary Pump

The above is the description of the pump and motor set installed at the Municipal Pumping plant at Buffalo, N. Y.

On account of the exceedingly satisfactory operation of this equipment, the Buffalo Authorities have been considering the installation of a second set.

On the morning of November 22nd, the old steam pumps met with an accident, and in this crisis the electrical pump did yeomans service.

The story is told by the Buffalo News of Nov. 23d as follows:

"The accident at the waterworks pumping station has solved one question of vital importance to the public, for it has ended the dispute with reference to the installation of another big electrical pump at the station. Action was taken this morning in a conference between Mayor Adam, Col. Ward and others for the purchase of another big electrical pump at once.

For more than a year past there has been strife between Col. Ward and other officials regarding the awarding of the contract for another electrical pump. Col. Ward recommended the awarding of this contract to the Snow Steam PumpWorks, which built the big pump now in use. Other interests wanted to give the contract to the ———————— Co., on the claim that the latter company's bid was the lower, but Col. Ward stood pat for the local concern on claims that have been fully aired and upheld. Now the contract is to be awarded to the Snow Steam Pump Company." (Although in the name of the Snow Company, the pump is Worthington—the motor General Electric).

The Buffalo Express of the same date says:

"The electric pump saved the day, for it was not until nine o'clock last night that any of the steam pumps were started. The reservoir cared for the low pressure system during the day and the electric pump whirled and buzzed at the rate of 27,000,000 gallons every 24 hours, supplying the high pressure system. There was no part of the city without water for fire protection after 5 o'clock yesterday morning. The electrical pump filled every one.

* * * * * * *

The electrical pump which is doing the bulk of the work, is the one about which there has been so much controversy in the council. Councilman Barth was one of those who visited the scene yesterday. "That electric pump is worth $33,000 for today alone,' he remarked."

SCHENECTADY BRANCH A. I. E. E.

The local branch of the American Institute of Electrical Engineers has been rapidly increasing in membership until the rolls now show a total of over nine hundred names. The meetings, which are held weekly, are notable on account of the quality of the papers presented and by reason of the large attendance (averaging about 500) and the interest shown by the members in the discussions.

On November 2nd, Dr. S. A. Moss, of the General Electric Works at Lynn, gave a lecture on Gas Turbines, which was of peculiar value, as the speaker is thoroughly conversant with the latest improvements in this line, and the information was definite and authoritative. The lecture was illustrated by charts.

One of the features recently inaugurated by the Branch is a monthly debate upon some subject of interest to engineers. There are no definite assignments of speakers for affirmative and negative, all members being free to speak; and, as an incentive, a free trip to New York to attend the monthly meeting of the Institute in that City is awarded to the two participants, who deliver the best arguments on each side of the question.

Such a debate took place on November 9th, subject under discussion being Municipal Ownership. Mr. C. McMillan won the award for the affirmative, and Mr. C. H. Hill for the negative. Mr. C. H. Schaeffer received honorable mention for the paper which he presented.

At the meeting of November 16th, Prof. W. S. Franklin read a paper upon the Second Law of Thermo-dynamics. The lecture was illustrated by charts, and the subject was treated in an entirely original and new way, Prof. Franklin's idea being that the fundamental principles of Thermodynamics were matters of intuitive knowledge. He elaborated this idea, drawing parallels between Thermo-dynamic phenomena and various occurrences in nature. He stated further that the Science of Mechanics was inadequate to cope with most of nature's manifestations, such as wind storms, conflagrations, etc.

On November 23rd, Mr. F. O. Blackwell, of New York, delivered an illustrated lecture upon "Recent Hydro Electric Developments". In this lecture he compared the engineering incidental to plants of low head and great volume of water and that of high head and relatively little water. For the former he selected the Electric Development Company's plant, of Ontario, and for the latter the Necaxa plant of Mexico. The lecture was copiously illustrated by lantern slides.

Beginning with the Niagara plant, Mr. Blackwell first considered the tunnels, wing wall, and other engineering undertakings connected with the introduction of the water to the wheels and its removal. He then described the power house turbines, wiring, switchboards, etc., dwelling upon the installation of the transformers, each in its individual fire-proof room. The transmission line was also fully described.

Mr. Blackwell's paper on this installation can be found in full in the "Proceedings of the Sixteenth Annual Convention of the Canadian Electrical Association at Niagara Falls, June, 1906".

Mr. Blackwell then took up the Necaxa plant, and called attention to the plateau nature of the country where the development has been made. He described the system of storage reservoirs in use, the pipe lines, and particularly the construction of the high pressure pipes leading from the edge of the Falls to the power house. He next took up the power house itself and machinery therein. The wheels are of the impulse type and are unique in having vertical instead of horizontal shafts. The method of transmission and the construction of the transmission line was fully explained, as was also the commercial aspects of the development, such as the utilization of the power in the city of Mexico and at El Oro.

After the reading of the paper, Mr. D. B. Rushmore gave a very interesting talk, in which he pointed out the difficulties an engineer meets with and the various problems he has to solve in undertakings of this description.

On December 1st, Mr. W. S. Andrews, of the General Electric Co., read an extremely interesting paper on "Pioneer Work in Incandescent Lighting". Mr. Andrews showed a great many pictures illustrative of his subject.

Beginning with a set of photographs of Thomas A. Edison, showing the Inventor at various ages, he went on to give a description of the laboratory at Menlo Park and the early developments of electric lighting. Among other installations, he mentioned the Steam-ship "Columbia", which in 1880 was equipped with the first commercial lighting plant ever installed. He described the first central station, which was equipped at Menlo Park and used to light Mr. Edison's residence and those of his neighbors.

Mr. Andrews described in some detail the various vicissitudes incidental to the problem of insulating the first conduit. He told about the early dynamos, which, though of peculiar appearance to modern engineers, are in many cases still of service, after more than twenty years of operation. He also spoke of the first electric locomotive; a 7 h. p. machine, which was equipped with a compound winding, showing that Mr. Edison was conversant with the advantage attached thereto. The various early installations were then taken up in order, after which he described the development of the incandescent lamp, beginning with the platinum-magnesia lamp, the early spiral filament lamp, and the carbonized filaments made of different materials.

Mr. Andrews called attention to the excellent work of Luther S. Tieringer and said that the world was probably more indebted to him than to any one else, except Edison, for the development of incandescent lighting.

At the first meeting in December, Dr. Steinmetz read a paper on the "Transformation of Electric Power into Light". Dr. Steinmetz pointed out that, in general, where light is produced, it is really in the nature of a by-product of heat. He showed that the higher the temperature produced, the greater would be the proportion of energy radiating in the form of light, but that, on the other hand, while the energy efficiency is increased, the life of the lamp or other appliance is lessened, thus reducing the commercial efficiency. Dr. Steinmetz pointed out the fallacy of disregarding the effect of color in estimating efficiency, as the amount of apparent illumination depends largely thereon. He gave as an instance, the flaming arc, which looks brilliant near by and loses this property at a distance, whereas the mercury arc has the reverse effect. He stated that a true estimate of illumination must take into consideration the element of distance, and that, after all, about the only true comparison is the reading test at different distances. He spoke of the mistake of illuminating by chandeliers, and the possible production of heavy shadows when luminants are concentrated. He also mentioned the new metallic filaments of high efficiency and their promise of increased illumination.

After the paper, Mr. P. D. Wagoner spoke of central station men fearing the introduction of metallic filament lamps as conductive to less current consumption. Mr. Wagoner said that this difficulty would probably not arise, as the tendency was for increased illumination with same expenditure, rather than same illumination with decreased expenditure.

Mr. E. J. Berg brought up the question of static discharge for illumination as a commercial possibility. Mr. Steinmetz stated that, while the efficiency is high at high frequencies, these are difficult to procure, and at low frequencies efficiency falls off materially.

December 15th was debate night, the topic for discussion being the "Metric System". Mr. Rushmore presided, and, after an introductory talk, called upon Mr. E. B. Raymond for remarks. Mr. Raymond stated that the question of adoption of the metric system was not one as to the value of the system itself, but whether the expense attendant upon such introduction was justifiable, as, in his opinion, it would necessitate an entirely new outfit of tool equipment; while the old tools would have to be retained for the purpose of producing repair parts of machines already installed. He did not think that a large company would inaugurate a change until financial saving could be demonstrated.

Mr. Raymond read a letter by Mr. Riedell, in which he spoke of the difficulty in translating specifications for foreign orders into the English system.

Mr. Goodspeed next spoke of the scientific origin of the metric system. He also pointed out the awkwardness of the English system of measure in the matter of subdivision of the inch and the advantage of the metric system in this respect. He did not think that the unfamiliarity of workmen with the system was of much moment, but thought that it was simply a case of accustoming themselves to the new units, and cited several plants where the change had been made without difficulty. He stated that the main objection lay in the equipment of the machine shop, but believed that the change is sure to come and suggested that we might as well make it gracefully, especially as there was much to be gained by having the men accustomed to the system before radical measures were made necessary either for commercial reasons or by law.

Mr. Hart pointed out the advantages in machine work due to the fact that engineering formulae are in metric units, and quoted S. P. Thompson in this connection. He spoke of the difficulty of the metric system in connection with screw threads.

Mr. Fielding reiterated the arguments in connection with the commercial phase of the matter.

Mr. Poor spoke of the saving to be made in the engineering department by the use of the system, and questioned whether it would not off-set the expense of introduction in shops.

Mr. Hewett pointed out the advantage of a duodecimal system, on account of its many factors; the inconvenient dimensions of the meter; and claimed that the metric system was not of such universal practice as many thought, as America and England were the principal manufacturing nations, and both used the English system. He suggested the use of a foot of ten inches, and of sub-dividing the inch into tenths, thereby making the decimal system applicable.

Mr. A. E. Averrett spoke of the universal use of the slide rule and the awkwardness of the English system in this connection. In the matter of screw threads, he stated that, as there was really no good system at present, perhaps the metric system was as good as any.

Mr. J. W. Yorkston thought that the change to metric system would come with the change to a universal language, and he believes that if it is to come, the governments must force it, as no concerns will adopt it of their own volition.

Mr. Cravens, speaking of the necessity of carrying two sets of tools, said that, as machinery gets out of date rapidly, the old tools would very soon be dropped. He also spoke of the advantage to be gained by writing dimensions in one unit instead of feet, inches, and fractions of an inch.

NOTES

Mr. H. A. Kidder has recently left the Railway Department to take the position of Assistant Superintendent of Substations with the Interborough Rapid Transit Co., of New York.

* * *

Mr. H. A. Eisenhuth, a graduate of the Pennsylvania State College, who entered the Testing Department in 1903, left on the 15th of December to accept a position with the America Smelters Security Co., of St. Barbara.

* * *

Mr. H. H. Crowell has resigned the position of Manager of the Syracuse office to take the position of Expert with the State Gas and Electric Commission.

His successor has not as yet been appointed.

* * *

Mr. H. Comstock, who has had charge of No. 16 at night, is a graduate of Oklahoma State University and entered the Test in July, 1905. He left on the 12th of December for Mineville, N. Y., where he has accepted a position with the Witherby Sherman Co., which controls a large iron mine. Mr. Comstock will have charge of the electrical equipments.

* * *

Mr. R. H. White has left the Test to accept a position with the American Locomotive Co., of this City. Mr. White entered the Test during the summer of 1905, and before leaving had charge of floor test at night. In his new position he will have charge of the alternating current equipments.

He is a graduate of the University of Nebraska.

* * *

Mr. C. T. Wilkinson, of the Publication Bureau, lectured on Dec. 3d before the Local Branch of the A. I. E. E. at Pittsfield. Mr. Wilkinson spoke upon the subject of high tension direct current transmission and also gave a very interesting talk about his trip this summer with the Institute of Electrical Engineers, in Great Britain and on the Continent.

* * *

Mr. R. B. Matthews, formerly of the Publication Bureau of the General Electric Co., and later Chief Engineer of the Amsterdam Edison Co., has accepted a position in connection with the air brake and compressor exploitation in England and the Colonies. His headquarters will probably be in London.

* * *

Mr. J. T. Stockdale of the Power and Mining Department, was married in Baltimore, on the 17th of December to Miss Anne Poultney Robinson, daughter of William Leslie Robinson. Mr. and Mrs. Stockdale sailed for Jamaica on the 20th and will be at home at their residence on Front Street, Schenectady, after the 15th of January.

Mrs. Stockdale is a sister of Mr. Conway Robinson of the A. C. Engineering Department.

* * *

Mr. F. L. Taylor, of New York, attended the meeting of the Plumbers' Association on December 4th at 155 East 58th Street, and took with him a number of circulars for distribution and two of the General Electric Company's luminous radiators which he connected to the circuit, demonstrating their operation to the members of the Association.

He was rewarded for his business foresight by taking fifty orders for luminous radiators at the meeting, and the immediate result following was a further order for fifty more, with the privilege of making the number one hundred within sixty days.

* * *

Mr. W. I. Slichter delivered a lecture on Dec. 14th before the Local Branch of the A. I. E. E. at John Hopkins University. The lecture consisted in a general comparison of the single phase A. C. railway system and 600 volt D. C., pointing out the advantages of the single phase system, with particular reference to the transmission and distribution of power, and the limitations and disadvantages of that system caused by the poorer characteristics of the single phase motor as compared with the direct current motor. It was pointed out that at free running conditions, the single phase motor closely approached the direct current motor in efficiency and output per lb. of material, whereas at lower speeds, the direct current motor was superior in these characteristics. It was deduced therefrom that the proper field for the single phase motor consisted in a service of long distance runs at high speed with few stops, and curves were shown giving the relation between schedule speed possible with a given motor of the two types for various distances between stops. These curves showed that with a distance between stops of less than one mile, the direct current motor was able to make a better schedule speed, and that with a distance between stops greater than 1½ miles, the A. C. motor was able to make a better schedule speed.

It was pointed out that a particularly valuable feature in the A. C. motor was its ability to run as a D. C. motor over the existing D. C. systems where the stops were frequent, while the interurban running where the stops were infrequent, could be made on alternating current.

* * *

Mr. J. S. Knowlson has left the Test to go into Mr. Haskins' Department. He is a graduate of Cornell University.

* * *

Mr. O. A. Clark has succeeded Mr. C. I. Burkholder as assistant to Mr. Rohrer. Mr. Clark has been in Mr. Rohrer's office since April, at which time he left the Test.

SALES NOTES

The Great Northern Paper Company have purchased from the General Electric Company an additional 1000 kw. three-phase transformer, and a 300 kw. transformer, to add to the equipment described in the last issue of the Review.

* * *

The Great Southern Lumber Company, of Bagolusa, La., have ordered from the General Electric Company, a large electrical equipment for their mills.

The generating equipment comprises
Two ATB. 72-500-100-2300 generators.
One ATB. 72-200-100-2300 generator.
Two MP 6-30-305-125 marine exciters, with controlling switchboard.

The motor equipment will consist of 63 motors, aggregating approximately 2337 h. p.

The motors will be distributed and used as follows:

In Planing Mill No. 1.
Six I-8-35-900-K-440 Ds-2 for 15 in. matcher.
One I-8-35-900-K-440 for 12 in. matcher.
Two I-8-25-900 for 15 in. inside moulder.
One I-8-35 for No. 117 double surfacer.
Two I-8-35 for a 4 saw edger No. 256.
Nine I-8-35 for a 9 in. balancer.
Two 12-25 for heavy band rip saw No. 281.
One 12-25-600, for bevel side band re-saw No. 283.
One 14-55-514 for heavy re-saw No. 285.
Thirteen I-6-5-1200 for swinging cut off saws.
Three I-12-150-600 for double blower.

For Planing Mill No. 2.
One I-8-35-900 for 20 x 30 No. 1 Sizer.
One I-12-150-600 for Double Blower.
One I-6-5-1200 for Swinging cut off saw.
One I-8-35-900 for 15 in. balancer and matcher.

For Planing Mill No. 3.
One I-12-150-600 for Double Blower.
Five I-8-35-900 for 15 in. No. 94 matcher.
Three I-8-35-900 for 13 in. balancer and matcher.
Four I-6-5-1200 for Swinging cut off saw.
Two I-12-150-600 for Rough lumber shed, Double Blower.
One 8-35-900 Dry lumber sorter.
I-6-15-1200 Kiln Transfers.
Three H-60-100-2300-230/460 for Station No. 1.
Three H-60-75-2300-230/460 for Station No. 2.
Three H-60-100-2300-230/460 for Station No. 3.
Three H-60-275-2300-230/460 for Station No. 4.

The above motors are three phase, form 'K' 440 volt.

* * *

The following note was received too late to be incorporated in the item regarding the same subject, which was published in the last Review.

The Indiana Steel Company of Chicago, Illinois, has placed an order with the Chicago Office of the General Electric Company for the first of the synchronous motor driven generators for their new steel plant at Gary, Indiana.

The outfit rated ATB-8-530 B-375-6600 Volt, is direct connected to and mounted on common base with 1-MP-12-500-375-250 volt D. C. generator. The motor is designed for 250 volt excitation from the generator and is provided with amortisseur windings on the revolving field so as to be readily started from the line without the use of special starting device other than the standard compensator.

The entire equipment represents the latest design for this class of apparatus and is extremely compact, having but two bearings.

With the motor generator set is furnished a starting compensator, rheostats and switchboard panels.

The motor generator set with others to be purchased later will be used to furnish 250 volt power service for miscellaneous direct current reversing motors used for the operation of the rolling mill tables, cranes and similar work. The selection of the apparatus for this initial equipment was based on the well-known and very liberal guarantees, which cover General Electric apparatus, as well as on the superior electrical and mechanical design.

In addition to the foregoing, the Chicago office has received an order from the same customer for

Three -WC-25- 3000-22000/6600 volt, single phase water cooled transformers.

The transformers will be used to step up from the 6600 volt generator voltage in the Gary plant to 22000 volts for transmission to the cement plants of the Universal Portland Cement Company at Buffington, Indiana, six miles distant. Incidentally, the power system of the Illinois Steel Company of South Chicago, Illinois, will be coupled to the power system of the Indiana Steel Company at Gary through the substation at Buffington, Indiana, and by means of these transformers, so that in case of emergency, considerable assistance can be rendered to either system by the other; or the cement plants may be operated from either system independently. The motors for the cement plant are also of General Electric manufacture as noted in the November issue of the Review.

It is worthy of note that the order for the above transformers was secured purely on the basis of the class of apparatus furnished, since the General Electric water cooled transformers are rated at 40 deg. C. rise above the temperature of the incoming water, which is 15 deg. C., whereas competitive transformers are designed for 40 deg. C. rise on the basis of an initial temperature of 25 deg. C. This important difference requires much greater weight both of iron and copper for the General Electric transformers and a correspondingly greater overload capacity and lower absolute temperature of the windings thereby insuring the permanency of the insulation.

The item in the November Review regarding the Hudson Companies' equipment, was over looked when correcting the proof. The list of apparatus should have read:

Two ATB 4-3000-750-11000 volt Curtis steam turbine-generators.

Two ATB 4-6000-750-11000 volt Curtis steam turbine generators.

One hundred G. E. 76 motors, (160 h. p.)

Fifty multiple unit control equipments.

Eleven HC 12-1500-250-550 volt rotary converters.

Thirty-six AB 25-550-9500/9750/10000/10250-10500 450 volt transformers. * * * *

The rolling stock will consist of fifty motor cars each equipped with 2 G. E. 76 (160) h. p. motors, and Sprague General Electric Type M control.

* * *

The Brunswick-Balke-Collender Company has ordered from the General Electric Company one ATB 72-300 kw. -100 RPM, 480 volt engine type generator with exciter, and forty-eight induction motors, Form K, in sizes varying from 3 to 35 h. p. This equipment to be used for operating their new factory at Long Island City, New York, for the manufacture of billiard tables and supplies, the motors being principally used for operating wood-working machinery.

In addition, there are also two synchronous motors, type ATB 6-50 kw.-1200 RPM. each motor to be used for driving shafting requiring about 20 to 25 h. p. The excess capacity of these motors, over that required for the mechanical output, is used to raise the power factor of the system in the following manner:

The fields of the motors are excited from the exciter of the generator, and the motor field rheostats are set so that the motor current is always leading in phase. A Tirrill regulator is connected to the exciter in the usual way; any increase or decrease in the load on the generator causes the Tirrill regulator to raise or lower the exciter voltage, and consequently varies the angle of lead of the synchronous motor current. As the angle of lag of the inductive load varies, roughly speaking, with the load on the generator, this method of control, therefore, automatically tends to make the power factor of the system constant irrespective of the load.

The plant also includes necessary equipment of lighting transformers for supplying incandescent lighting on 3-wire, 110-220 volts.

* * *

The New York Times Company has installed on top of their 27 story building at the corner of Broadway & 42nd Street, New York City, one Navy Standard 30 inch Projector, this being installed primarily for indicating the results of the recent election by a pre-arranged code of signals. While such installations have been made for temporary use at various times, this is the first example of permanent installation of this type in New York City. The Times has used this searchlight as an advertising feature and it has attracted considerable favorable newspaper comment.

The following apparatus comprises the complete electrical equipment for the road to be built between Sherman and Dallas, Texas.

Power Station.

Two-1000 kw. 2200 volt, three-phase, 25 cycle, Curtis turbo-alternators.

Two-35 kw. turbo exciter sets.

Seven-330 kw. 19100/2200 volt, single phase air blast step-up transformers.

Two-Blower sets.

Switchboard for operating the above apparatus.

Sub-Stations:

Five-Sub-station equipments, each consisting of one-300 kw. three phase rotary converter, 45 KVA. oil cooled reactive coils.

Three-110 kw. 19100/370 volt, oil cooled step-down transformers.

Switchboard apparatus for controlling same.

One Portable Sub-Station:

To contain one 300 kw. rotary Converter outfit.

Motor Equipments:

Fifteen-four-motor GE-73 equipments with Sprague General Electric Type M. control.

Fifteen-straight air brake equipments with CP-22 compressors.

This road will be 63 miles in length, will be single track, and will have a 60 to 100 ft. private right of way.

It will run through the city streets in Dallas and in Sherman and for most of the way between the two cities will parallel the steam road. The run between the cities will be in two hours and a half, 15 minutes of this time being upon the city streets, where the speed must be lowered.

Dallas is a city of 80,000 population, Sherman about 20,000, and the road passes through an intervening corporation of 20,000 more.

The generating station will be located at McKinney, which is about mid-way between the two cities.

The transmission voltage will be 33,000 (19100 volts, connected in Y with grounded neutral system). The road will run through what is known as the "Black Belt", which is a strip of land about 100 miles wide and 300 miles long, the earth of which is peculiarly dark and exceedingly rich, the richest certainly in Texas, and probably as rich as any in this country.

It is intended to have the road in operation by January 1st, 1908.

* * *

The Chicago Office of the General Electric Company secured from the Chicago Edison Co. an order for switchboard devices, including:

20 horizontal edgewise ammeters.
35 horizontal edgewise indicating wattmeters.
20 horizontal edgewise voltmeters.
15 horizontal edgewise power factor indicators.
6 horizontal edgewise frequency indicators.
80 potential transformers.
25 line drop compensators.
30 Thomson Recording IS-2 wattmeters and
115 current transformers.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

*Illustrated

Central Station Work in Vermont

[Elec. Wld., Nov. 3, 1906, p. 849]

This article describes several of the central station companies now operating in Vermont, including:

The Burlington Light & Power Co., with about 1500 KW in General Electric alternators, and a Brush arc machine in the Winooski hydro-electric plant.

The consolidated Lighting Co., of Montpelier, with several hydro-electric plants containing a number of General Electric machines, and a steam plant with a 2500 KW engine-driven General Electric alternator. The sub-station machinery and transformers, and all of the house transformers, are of General Electric make.

The St. Johnsbury Electric Co., operating a number of small power plants, with an electric equipment comprising General Electric and Stanley alternators.

Electric Railway Power at Rutland, Vermont

[Street Railway Jour., Nov. 24, '06, p. 1000*]

The Rutland Railway, Light & Power Company controls the electric railway, light and power service, as well as the gas supply of the community, and obtains power from water-power developments, and an old steam plant. The equipment of the latter comprises about 1000 h. p. in engine-driven generators, and will probably be shut down entirely in January, 1907.

The hydro-electric plant will ultimately have four main units, at present it contains:

Three 400 kw., 13,200 volt, 25 cycle, three-phase, revolving field generators, direct-driven by horizontal shaft water turbines.

Two 45 kw., 125 volt, turbine-driven exciters, and necessary switchboard installation.

Power is transmitted to a main sub-station at Rutland, with three 125 kw., 13,200-380 volt transformers, and two 150 kw., 600 volt rotary converters, one 280 cell storage battery, with 400 ampere-hour capacity; also, to the Castleton sub-station, with three 150 kw. transformers, and two 150 kw. and 200 kw. rotary converters, respectively. The entire electrical equipment is of General Electric make.

The New Power Plant of the Vermont Marble Company

[Electrical Age, December, '06, page 401*]

The plant of the Vermont Marble Company, in Proctor, Vt.,—which establishment is one of the largest of its kind in the world—includes a hydro-electric power development which is now in service, and which has a rated capacity of 2250 kw.

The power-plant is located at Southern Falls, Otter Creek, about 500 ft. east of the company's principal mills, and supplies not only current for the lighting and power of the marble company, but also for the lighting of Proctor, Vt.

There are installed at present, three 750 kw., 514 r. p. m. 480 volt, vertical shaft, three-phase alternators, direct-driven by 1200 h. p. water turbines, and with direct-connected 30 kw., 125 volt, exciters.

A motor-generator set, consisting of a 150 h. p. induction motor, direct-connected to a 100 kw., 250 volt, D. C. generator, for supplying direct current to a number of D. C. motors installed in the mills.

The power-house contains, also, a bank of three 300 kw., 400-11000 volt, single-phase, transformers, for feeding a 5.5 mile transmission line which goes over Albertson to the sub-station near the largest quarries of the marble company, located at West Rutland, Vt. The current is there stepped-down by means of the following:

One bank of three 150 kw., 10000-3300 volt transformers, one bank of three 150 kw., 10000-460 volt transformers, one 250 kw., 250 volt D. C. induction-motor-driven generator.

In addition to the power and lighting supplied for the marble company, the sub-station furnishes current for street arc lighting by means of a 50 light constant current transformer.

In the sub-station at Albertson there are installed:

A bank of three 100 kw. 10000-460 volt, single-phase transformers for general power and lighting, one motor-generator set, 75 kw., 250 volt D. C.

The machinery in the mills is group-driven by means of electric motors, in sizes up to 250 h. p. Electrically-driven channelers, and an experimental electric drill are used in the quarries.

The entire electrical equipment, including the extensive switchboards, is of General Electric make.

System of the Binghamton Light, Heat and Power Company, of Binghamton, New York

[Electrical World, Dec. 3rd, '06, p. 1033*]

Description of a progressive, medium sized electric power supply company, the power-house equipment of which includes:

two 500 kw., 2300 volt, 60 cycle, three-phase alternators, one of which is driven by an engine, and the other by a Curtis turbine.

The power house contains, also, some belt-driven units, including two 200 kw. three-phase generators and one 250 kw., 500 volt, direct-current generator.

A machine of special interest is a two-unit motor-generator set, consisting of a

150 kw., 500 volt., D. C. generator, direct-connected to a 200 kw., 2200 volt, three-phase machine, which can be used either as synchronous motor for driving the D. C. generator, or as three-phase alternator to be direct-driven from the D. C. machine.

The entire electrical equipment, including the extensive switchboards, are of General Electric make, as is also the street lighting equipment, comprising about 435 series alternating 6.6 ampere enclosed arc lamps and 448 incandescent lamps.

One of the principal power consumers is the Chenango Silk Mill.

About 100 motors are still being connected to the 500 volt D. C. circuit, but the company is changing over as fast as possible to A. C. supply, and there are at present installed about 450 h. p. in single-phase motors, which up to the present date, have caused no serious disturbance on the line.

In addition to the power and lighting supply in Binghamton, the power-house supplies both municipal and commercial lighting in the villages of Lestershire and Port Dickinson.

Station of the Wilkesbarre Gas & Electric Company, at Wilkesbarre, Pa.

[Electrical World, Nov. 24th, '06, p. 991]

Very interesting illustrated description of the modernizing of the above company's plant, which comprises at present:

one 500 kw. and one 600 kw., 2300 volt, 60 cycle, engine-driven, General Electric two-phase alternators,

one 750 kw. 2300 volt, 60 cycle, Curtis steam turbine generator,

two 50 kw. engine-driven exciters, in addition to a 20 kw. induction motor-driven exciter.

The power plant is supplying a number of sub-stations, equipped with General Electric rotary converters and constant current transformers, for 7.5 Amp., 60 cycle, enclosed arc lamps.

The business of the Wilkesbarre Gas & Electric Company, which is a consolidation of a number of smaller concerns, is stated to amount to about 3100 kw. in connected load; of which about 700 h. p. is due to motors, 325 kw. to street lighting and the remainder to general incandescent lighting.

Electrification of the West Jersey & Seashore Railroad. New System Put in Operation on an Important Branch of the Pennsylvania Railroad

Description of Power House and Sub-Stations

[Elec. Rev., Nov. 3, 1906, p. 717]

A complete description of this important work, which consisted in the electrification by the General Electric Company of a steam railroad from terminal to terminal. The electrical apparatus comprises the complete equipment of the power house with 2000 KW Curtis steam turbine units, and of the sub-stations with 500 KW and 750 KW rotary converters, with transformers, switchboards, and lightning arresters, all of standard General Electric design, and all installed in a short time after the closing of the contract. A large number of illustrations, including drawings and a map of the system, accompany the article.

Electricity In Mining

[Electrician (London), Nov. 23, '06, p. 226]

"Considerable improvements have recently been carried out at the Robinson Deep Mines, Johannesburg, including the addition of five new Babcock & Wilcox boilers, of 250 h. p. each, and two new Curtis steam turbine-generators of 500 kw. each, which now generate all the current required for power, lighting, and at the cyanide works, the three pumps of which are driven by independent electric motors".

INDEX

Page

A. I. E. E. Schenectady Branch 36

Alternators, Parallel Operation of, Some Features of, by Ernst J. Berg 20

Blowers and Exhausters, by Maxwell W. Day 17

Brunswick-Balk-Collander Co. 42

Generating Systems:
  Binghamton, N. Y., Light Heat and Power Co., System of 43
  Central Station Work in Vermont 43
  Vermont Marble Co., New Power Plant of 43
  Wilkesbarre, Pa., Gas and Electric Co., Station of .. 44
  (See also Traction).

Heating Apparatus, Manufacture of, at Lynn, by D. B. Gauchet 24

Hoists for Mining, Electric, by Leonard Wilson 27

Lumber Mills:
  Great Southern Lumber Co 41

Mining, Electricity in 44

Notes 39

Oil, Handling and Storing of Transformer Oil, by B. E. Semple 25

Paper Mills:
  Great Northern Paper Co 41

Pump, Motor Driven Rotary 35

Searchlights:
  New York Times Company's Projector 42

Steel Works:
  Indiana Steel Co. 41

Traction:
  Hudson Companies 41
  Texas Traction Co. Dallas to Sherman 42
  West Jersey and Sea Shore Railroad, Electrification of 28, 44
  (See also Generator Systems).

West Jersey and Sea Shore Railroad, Electrification of, by John R. Hewett 28

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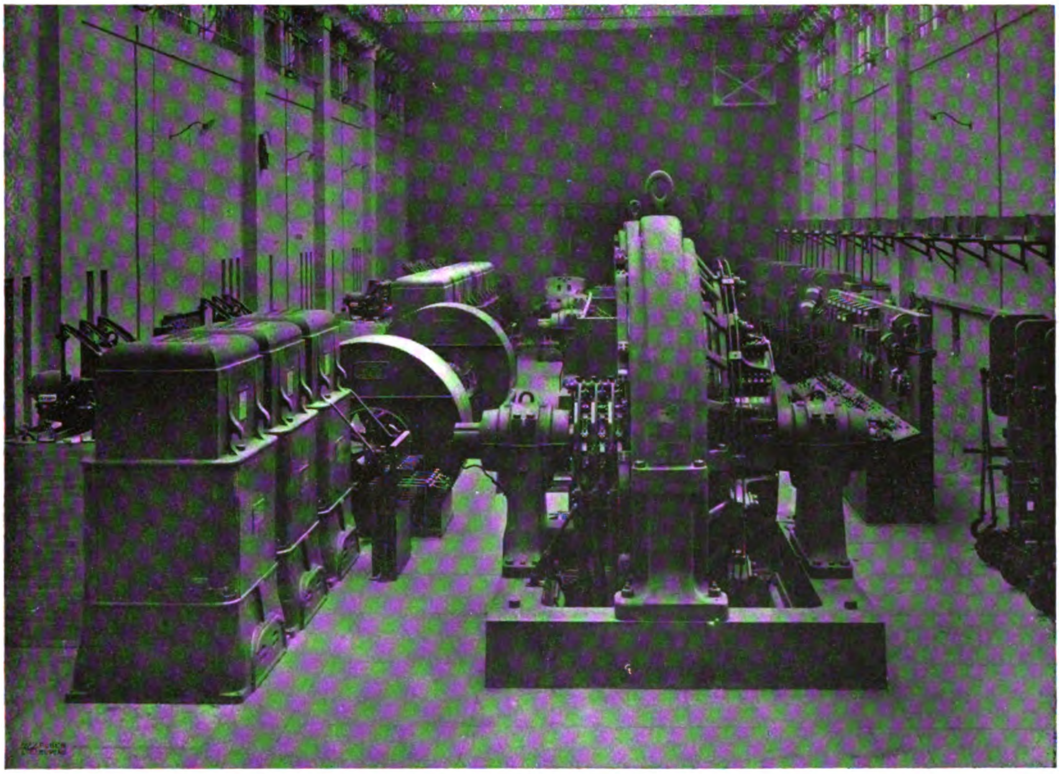
GENERAL ELECTRIC COMPANY REVIEW

Vol. VIII SCHENECTADY, N. Y., FEBRUARY, 1907 No. 3



Interior of Sub-station

ELECTRICAL EQUIPMENT OF THE NEW YORK CENTRAL & HUDSON RIVER R. R. CO.

By A. SMITH

The following is a brief description of the equipment necessary for the electrification of the New York Central Railroad from the Grand Central Station, New York City, to Croton on the Hudson Division and from Mott Haven to North White Plains on the Harlem Division, an aggregate distance of approximately fifty miles.

There are to be four tracks on each division, and the section near the Grand Central Station will be constructed on two levels; the express trains running on the upper level, which is about 10 ft. below the present level, and the local trains running on the lower level, which has the same elevation as the Interborough Subway tracks.

Electric locomotives will be used instead of the steam locomotives for hauling all through trains, and motor cars, run in trains, used for the local service between New York and the outlying towns and villages.

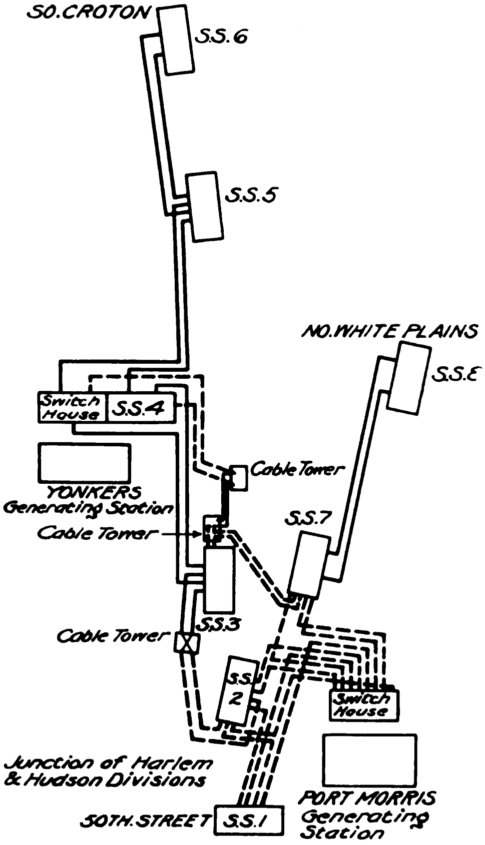

SO.CROTON
S.S.6
S.S.5
NO.WHITE PLAINS
S.S.8
Switch House
S.S.4
Cable Tower
YONKERS Generating Station
Cable Tower
S.S.7
S.S.3
Cable Tower
S.S. 2
Switch House
Junction of Harlem & Hudson Divisions
PORT MORRIS Generating Station
50TH.STREET
S.S.1

Diagram of High-Tension Feeders
(Broken Lines, Underground; Full Lines, Overhead)

As a very thorough description of these stations appeared in the Street Railway Journal, Sept. 29th, 1906, and Nov. 3rd. 1906, this article will be devoted entirely to such uncommon features as have been mentioned only in a general way or not at all, in the above periodical.

At the writing of this article, there is equipped one power station, four sub-stations, nine circuit breaker houses, and one lightning arrester tower. Local motor car trains between Croton and Grand Central Station are running on regular schedule, but only run with electric power from High Bridge on the main line, and Woodlawn on the Harlem Division to Grand Central Station.

The equipment on order, or in the process of construction, or installed, is as follows: All of the equipment mentioned was supplied by the General Electric Company with the exception of the rotary converters.

Two Power Stations, One at Port Morris and One at Yonkers

each containing:

4- 5000 kw. 11000 volt, 25 cycle Curtis steam turbine-generators (ultimate equipment six),
2- 150 kw. 125 volt turbine-driven exciters,
1- 150 kw. 125 volt motor-driven exciter,
47- "H-3" oil switches in the Port Morris station,
35- "H-3" oil switches in the Yonkers station,
2- 200 kw. 11000/220 volt 3-phase auxiliary transformers,
1- 74 cell, 1200 amp. one hr. storage battery,
1- 150 kw. 11000/22000-30,000 volt single-phase testing transformer,
Complete switchboards and auxiliaries.

Eight Sub-stations Located as Follows:

No. 1—50th Street & Lexington Ave.
No. 2—Mott Haven Junction.
No. 3—Kingsbridge.
No. 4—Glenwood (immediately adjoining Yonkers Power House).
No. 5—Irvington.
No. 6—Ossining.
No. 7—Bronx Park.
No. 8—Scarsdale.

	Sub-Stations.			
	1-2	3	*4	5-6-7-8
1500 kw. rotary converters (ultimate equipment five)	3 each			
1000 kw. rotary converters (ultimate equipment five)		3	3	3 each
550 kw. single-phase transformers (ultimate equipment fifteen)	9 each			
375 kw. single-phase transformers (ultimate equipment fifteen)		9	9	9 each
260 kw. motor booster sets (ultimate equipment two)	2 each	2	1	1 each
120 kw. single-phase transformers for boosters (ultimate equipment six)	6 each	6	3	3 each
7.5 kw. exciter generators for boosters	2 each	2	2	2 each
15 kw. D. C. motor generator set	1 each	1	1	1 each
Storage battery ranging from 2250 amperes to 4020 amperes 1 hr. in different stations	1 each	1	1	1 each
11000 volt, 300 ampere "H-3" oil switches	Total	76		
4000 ampere electrically operated switch & circuit breakers	Total	149		
Complete switchboard equipment	1 each	1	1	1 each

*Ultimate equipment three rotaries.

Nine Circuit Breaker Houses, each Equipped with 6-4000 Ampere Electrically Operated Switches and Circuit Breakers

Thirty-five 96-ton 2200 h. p. Electric Locomotives

Complete Motor and Multiple Control Equipment for 125 Coaches

Complete Motor and Multiple Control Equipment for 6 Combination Baggage and Mail Cars

Panels and Necessary Control Equipment for 55 Trail Cars

Cable

Main Station

No high tension cables or connections, with the exception of the lead covered alternator cables which are in clay ducts in the concrete floor, enter the turbine room. All the oil switches and high tension bus-bar compartments are located in a separate building 40 ft. from the Power House and known as the "Switch House". However, the station will be normally operated from an instrument and controlling board mounted on a gallery overlooking the turbines. On this gallery is also located the exciter and other auxiliary switch-boards.

To provide for emergency conditions, and for the purpose of testing, a duplicate controlling board and a similar instrument board have been installed in the switch house. These switchboards are divided into three independent sections, each section comprising two generators and one-third of the feeder circuits. All control circuits, oil switches and cables, are grouped in a similar manner. If an accident should occur to the controlling and instrument board in the turbine house, or if it is desired to clean or repair it, the control and instrument cables for one or all of the generators and their corresponding feeders, can be transferred to the switch house by operating one 24 pole cylindrical switch and two small lever switches for each generator. These switches are located in the switch house.

All main cables, control cables and instrument cables, running between the turbine house and the switch house, are lead covered and are laid in underground ducts.

The disconnecting switches for isolating the oil switches, are mounted in compartments covered by glass doors directly under the oil switches, so that they may be operated from the same floor. This arrangement eliminates any chance of the attendant operating the wrong disconnecting switches, which might be the case if they were located in the basement.

The alternators are "Y" connected and the neutral is connected through an 18 ohm, 300 ampere resistance, to a ground bus. A' current transformer is connected in the neutral lead, so that the switchboard attendant can plug in an ammeter, provided for that purpose, on any machine. The bus is grounded through current transformers with ammeters, to two independent ground plates. These ammeters are located in the general operator's room.

The object of this resistance, is to limit the current to an amount sufficient to operate a feeder oil switch if a ground should occur on any conductor of the high tension feeders; otherwise a ground on a triple conductor cable would undoubtedly develop into a severe short circuit between phases. For example, the voltage of one winding of the alternator is 6350 volts. and if two alternators are running, there will be a resistance of 9 ohms, 600 amperes to ground; therefore, if a dead ground should occur on one phase, there would be a flow of 700 amperes in that conductor through ground back to the neutral. This result would, of course, be somewhat reduced by the resistance of the ground and the conductor. The resistances are arranged in pairs, so that two may be connected in parallel, in case only one alternator is running. It is evident, that an ordinary ground would operate the feeder relay which is set at 300 amperes. While a dead ground would be

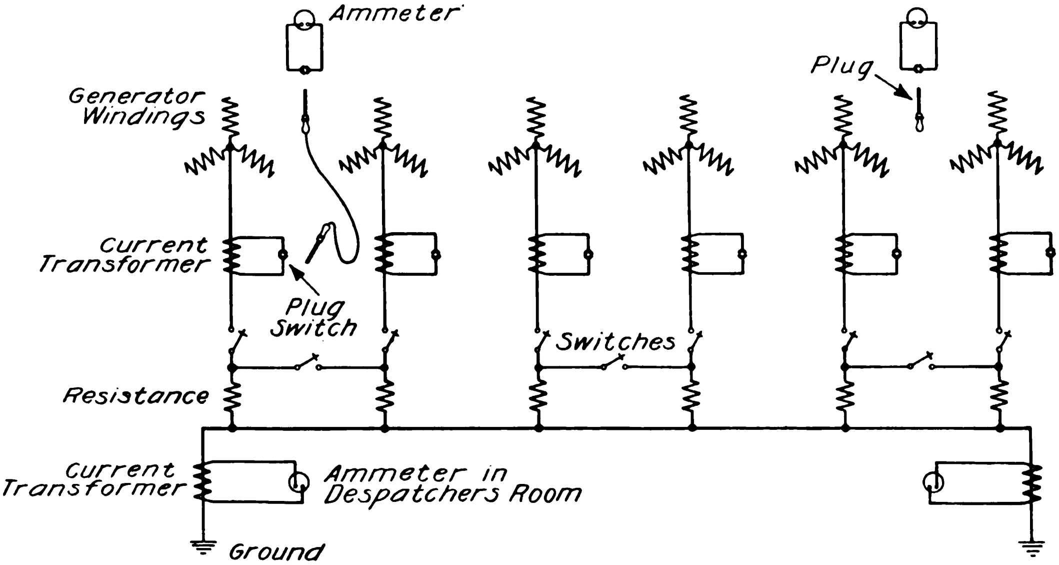
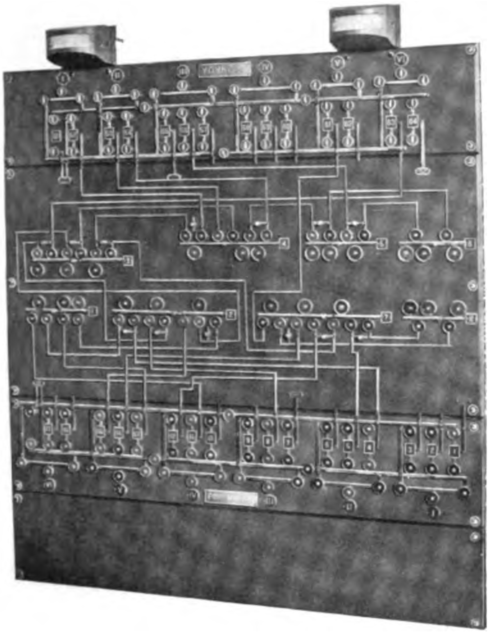


Diagram of Connections of Neutral Ground Resistances cut off without trouble, a slight ground would be indicated on the ammeters in the general operator's room.

The above arrangement differs from that in the Interborough and Manhattan Power Stations in New York, in that the latter stations have but a single resistance, and the neutrals are connected directly to the bus through disconnecting switches. This arrangement resulted in cross currents flowing between generators, so they are now operating with only one of the generators connected to the ground bus, which gives good results.

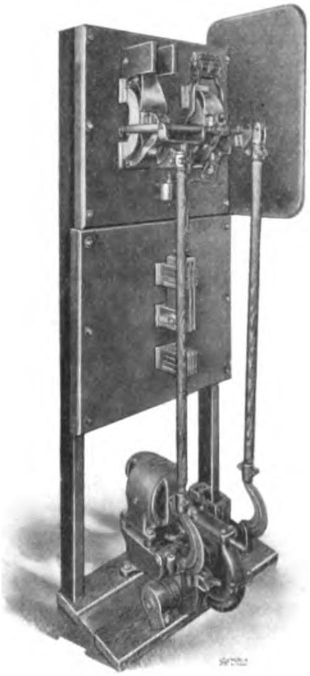


Record Board

By referring to the diagram of high tension feeders, it will be observed that any of the sub-stations bus-bars may receive energy from both power stations, therefore, if connections are so made, the power stations should be run in synchronism, and it would be necessary to synchronize all feeder circuits, as well as generators, before connecting them to the station busses. To accomplish this, and to prevent the operator from making a mistake, each oil switch controlling switch has mounted in connection with it, a synchronizing receptacle which has two of the six contacts connected in the closing circuit of the oil switch, thus preventing the closing of the oil switch until the synchronizing plug is inserted.

Signalling between the switchboard operator and the turbine attendant is accomplished by means of small illuminated bull's-eyes, on which are etched the words "Stop", "Start", "Fast", "Slow", "Stand-by". One set of these bull's-eyes, together with five push button switches, are mounted at each turbine and on each generator control panel. Normally, all lights are out and the inscriptions are only faintly visible. If the switchboard operator wishes to signal, he operates one of the push button switches, and the corresponding bull's-eyes at the switchboard and at the turbine are illuminated. The turbine attendant acknowledges the signal by closing a similar switch which cuts out both lamps. Attention is called to the signals by alarm bells which ring at the turbine and the switchboard until the signal is acknowledged. Signals may be transmitted from the turbine to the switchboard in the same manner and with the same set of signals. The connections of the signal system are very simple, only seven wires being used for each complete set.

In the despatcher's or general operator's room in the switch house of each power station, is a switchboard known as the "record board." This board, as will be seen from the accompanying illustration, shows the complete system of high tension connections, and is equipped with indicating lamps, switches and jacks, which are operated by the despatcher to keep a record of the generators. rotaries and feeder circuits in service. Oil switches in the adjacent power station are represented by indicating lamps connected in parallel with those on the control board. Oil switches in the other power station and the rotary converters are represented by discs or jacks, enameled green on one side and red on the other, which are turned with the red side out to indicate if a switch is closed or a rotary is running. While there is a record board in each power station, only one will be used at a time. All messages are transmitted between sub-stations and power stations over private telephone lines.



Motor Operated Switch and Circuit Breaker

Sub-stations

The arrangement of the sub-stations is clearly shown in the accompanying illustration and resembles our standard layout with a few exceptions. Electrically operated circuit breakers and switches are used to reduce the amount of copper in the station and to simplify the duct layout for the D. C. feeders. The D. C. side of each sub-station faces the track, and the D. C. feeders drop down from the circuit breakers into manholes and directly to the tracks. There are, therefore, no longitudinal runs of A. C. or D. C. cable in the station, but of course, it is necessary to run the positive, negative and equalizer bus-bars the full length. The positive bus-bar can be made of small cross section, as the rotary and feeder circuit breakers are intermingled.

The electrically operated switch and circuit breaker employed in the sub-stations and in the circuit breaker houses, differ only in the voltage of the motor and auxiliary coils, the former operating from 125 volt and the latter 600 volt control systems.

When the control switch is thrown to the open position, the circuit breaker opens; when thrown to the closed position, the switch opens, the circuit breaker closes and then the switch closes; these operations being performed automatically after the controlling switch is closed for an instant. About five seconds is required for the complete operation, from the time the controlling switch is closed, and the indicating lamp does not indicate "Closed" until the cycle is complete.

The mechanism is operated by a motor, and provision is made for operating it by means of a hand crank. The breaker and switch may also be operated independently by detachable handles.

Two methods of starting the rotaries in the sub-stations were adopted. Ordinarily, they will be started from the D. C. side, but in case of emergency, may be started from the A. C. side by using the one-half and three-quarter voltage taps on the step-down transformers. When started D. C., the customary starting resistance and switch is employed; but instead of adjusting the rotary field rheostat to obtain synchronous speed, the rotary is thrown in when near synchronous speed by practically cutting off the shunt field and entirely disconnecting the D. C. source. This is done by two operations on a 5 P. D. T. field break-up switch, one mounted on each rotary panel. When the rotary is running about synchronous speed, as indicated by the synchronism indicator, the switch is pulled out into a set of resistance clips which inserts in each section of the field, a comparatively high resistance, thus reducing the field current considerably. This operation closes two auxiliary switches, the one tripping the D. C. circuit breaker and cutting off the source of power, while the other closes the oil switch in the high tension side. The second operation is to re-close the switch, in which position it stands when the rotary is running. The lower throw of the switch is for reversing the field to "Slip a pole" if necessary when starting from the A. C. side.

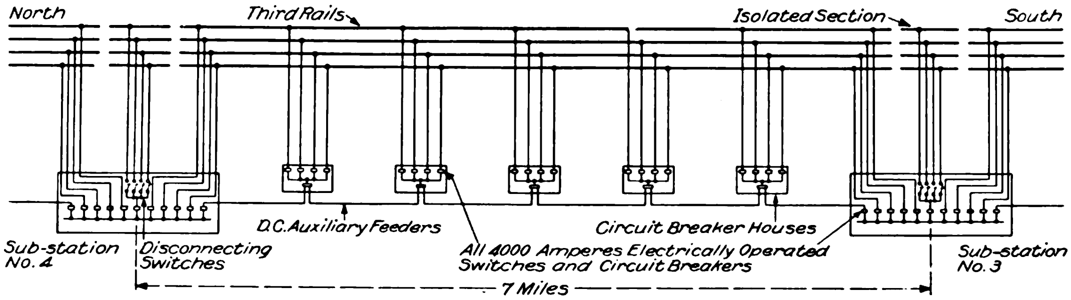


Diagram Showing Third-Rail Feeder Connections

The preceding diagram shows the method of connecting the positive feeder cables to the third rails. From each intermediate sub-station are four feeders feeding the four tracks North, and four feeders feeding the four tracks South. Directly in front of the sub-station is an isolated section somewhat longer than the ordinary train, which is fed from an independent feeder. If a ground should occur on a third rail South, the isolated section would not ground the third rail North through the train bus.

In addition, there are auxiliary feeders which feed the third rail at intervals between the sub-stations. As trains are not likely to be running on all four tracks at the same time, it was estimated that a single feeder feeding all tracks would be sufficient, but in order to avoid tying the tracks together at these points, which would cripple all the tracks if an accident should occur on one, circuit breaker houses were installed at these points and controlled from the sub-stations.

Each circuit breaker house contains six 4000 ampere electrically operated switches and circuit breakers, as shown in the accompanying illustration. Four breakers feed directly the third rails through the one breaker which is connected to the auxiliary feeder; the sixth breaker is a reserve, and may be used as a substitute for any one of the others by throwing the lever switch on that panel into the lower position. The control circuit is transferred in the same manner by small lever switches. Thus, complication in operation at the sub-stations is avoided, and the number of control wires required is no greater than if only five breakers were installed.

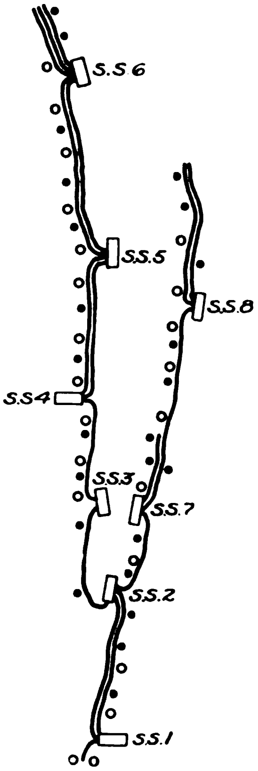


Diagram of D. C. Feeder Cables
(Solid dots, Circuit Breaker Houses, Initial Installation: Circles, Circuit Breaker Houses, Possible Future Installation)

Each circuit breaker is controlled by a single No. 12 B&S wire from the sub-station which feeds it. This wire also indicates at the sub-station, by means of lamps, the opened or closed position of the switch and circuit breaker. In order to obtain a more constant voltage, and to always have 600 volts available at the same point in the circuit breaker houses. separate positive and negative busses, each consisting of two No. 12 B&S wires in multiple, are run from each sub-station. An additional wire is run to each sub-station which operates an alarm bell in event of the automatic opening of any circuit breaker.

Cable

Various methods of installing, insulating and protecting the cable throughout the system were employed, depending on the local conditions as described in the following:

From 50th St. to 57th St. and in certain sections above the Harlem River, the cable has a paper and lead covering and is laid in underground ducts.

From 57th St. to 110th St. the cable has a paper and lead covering and is laid in iron pipes in the tunnel, or in iron pipes supported on the wall. This cable was made in lengths of 400 ft. each and drawn into iron pipes in the Company's yards. The pipes and cables were then transferred to flat cars and taken into the tunnel, or on the structure, and transferred in full length to the proper location. The cables were joined in the open sections between the pipes, and covered by large iron sleeves. The cables were installed in this method on account of the limited space in the tunnel and on the structure which was available without the extended interference or traffic.

From 110th St. to the Harlem River the cable was laid in iron pipes on the structure, but owing to the vibration of the structure, which would be likely to crystallize the lead, the cables were protected by 1 in. by 1-16 in. galvanized steel bands wrapped to break joints. Since moisture would undoubtedly reach the insulation on account of the absence of the lead sheath, varnished cambric was used for insulation instead of paper.

Across the Harlem River the regular armored sub-marine cables were used. These cables, to the number of 34, furnished by the General Electric Company and other companies, were laid in two layers. The lower layer was separated from the upper by wooden boxes about 1 ft. square laid at right angles to the cables at intervals of about 10 ft. The intervening spaces being filled with silt, etc.

Throughout the northern part of the system, as will be noted from the diagram, overhead lines are used and supported on steel poles. These poles carry the high tension lines, the D. C. feeders, the control cable and the signal cables.

There was also furnished for the control of the circuit breakers in the circuit breaker houses, cables made up of No. 12 B&S wire with paper insulation around each conductor and a lead covering over all. This cable which consists of 11, 17, 23, 29 or 35 conductors, was furnished in various lengths to a total of about 42000 ft. The insulation and protection of the cable is the same as the main cable previously described, with the exception of that part laid on the structure which has rubber insulation instead of varnished cambric.

Taking into account all the difficulties of installation, it is interesting to note that the entire layout of cables stood the required test with the exception of one joint and one length of cable.

The following gives the sizes and description and the approximate amount of each style of cable furnished by the General Electric Company:

50th to 57th St. and in Sections North of the Harlem River, in Under Ground Ducts

36000 ft. 3-conductor, No. 4-0 11000 volts, paper and lead.

13000 ft. single conductor, 1,000,000 C. M. cable, 600 volts, paper and lead.

4100 ft. single conductor, 1,250,000 C. M. cable, 600 volts, paper and lead.

57th to 110th St. in Iron Pipes in Tunnel or in Iron Pipes on the Walls

55000 ft. 3-conductor, No. 4-0 B&S cable, 11000 volts, paper and lead.

22000 ft. single conductor, 1,000,000 C. M. cable, 600 volts, paper and lead.

5700 ft. single conductor 1,250,000 C. M. cable, 600 volts, paper and lead.

110th St. to Harlem River, in Iron Pipes on Structure

25000 ft. 3-conductor, No. 4-0 B&S 11000 volt varnished cambric and steel banding.

6300 ft. single conductor 1,000,000 C. M. cable varnished cambric and steel banding.

6300 ft. single conductor 1,250,000 C. M. cable varnished cambric and steel banding.

Across the Harlem River

3000 ft. 3-conductor, No. 4-0 B&S armored sub-marine cable.

3700 ft. single conductor 1,000,000 C. M. armored sub-marine cable.

700 ft. single conductor 1,250,000 C. M. armored sub-marine cable.

2800 ft. single conductor 1,250,000 C. M. bare cable, tinned.

TANK CONSTRUCTION FOR TRANSFORMERS

By J. J. FRANK

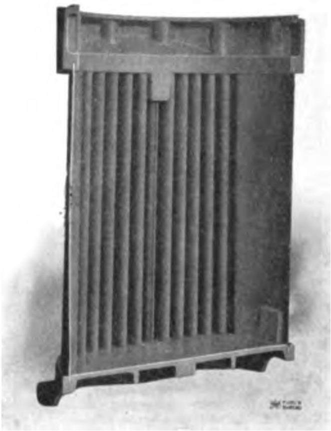
For a number of years the Engineers of the Transformer Department have defended the one piece cast iron corrugated tank as the only satisfactory construction; pointing out the weakness of the flimsy thin metal tank by calling attention to the liability to leak oil at the soldered seams and at the joint between the base and the sides, as well as the danger that such seams would be opened by a slight blow or by external heating of the transformer, thereby increasing the liability to fire. A further objection was that the weakness of such thin metal tank necessitated the separate shipments of the tank and the transformer proper. The one objection to the cast iron tank was its great weight.

Feeling, however, that some effort should be made to overcome this disadvantage of weight, the Engineers of the Transformer Department developed a one piece tank in which this objectionable feature is eliminated, and in which all the other desirable features are retained. This construction is accomplished by using corrugated sheet steel without soldered seams and having the base cast fast to the sides.

The seams of these tanks are welded by the electric arc using absolutely no flux of any kind to assist in the union of the two sides of the metal. The amalgamation of the cast iron base to the sides is obtained by an improved peculiar detail in the shape of the base, whereby in casting, practically all of the cast iron flows over the edges of the sheet steel, thereby melting the edge and forming a perfect union. The method of welding seams and the union of the cast iron base to the side, is very clearly brought out in the attached photograph.

The thickness of the sheet steel is 1/16"; and the shape of the corrugation gives a sufficiently rigid construction to withstand the strain incident to shipment and installation of the transformer complete.

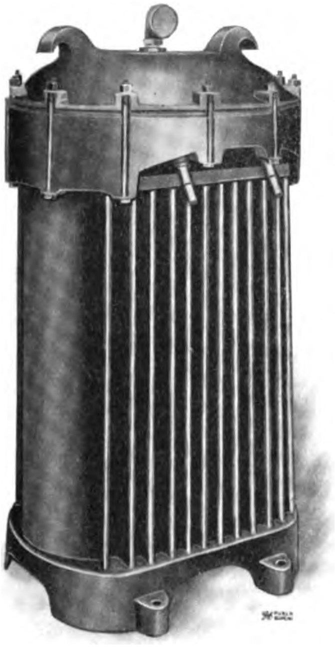
This tank construction has been extended to single and three phase core type transformers, oil cooled reactances for rotary converters, railway compensators for AC motors, and to subway transformers. For regular type "H" transformers, the base is cast fast to the sides; in the subway transformers, a cast iron rim is fastened to the top, to which the cover is bolted, and in the compensator for A.C. motors, a flange is cast on each end of the corru-



Section of Tank Showing Cast Welded Joint between Side and Base

gated side, to which flange both the covers are bolted.

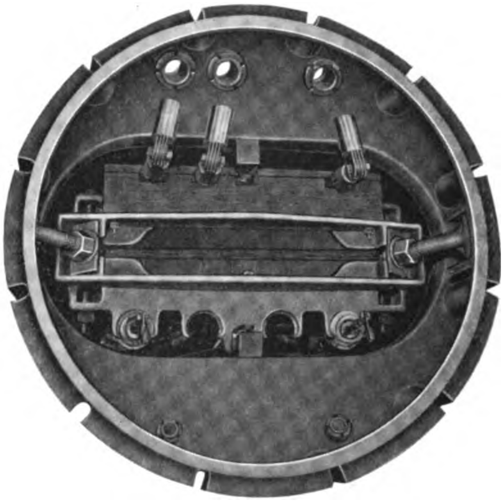
This tank construction gives a considerable flexibility in its application without losing any of the desirable features which it is intended to incorporate, as is evidenced by its general application cited above.



100 Kw. Type H Subway Transformer

Referring particularly to this application on subway transformers, it can be readily seen, by referring to the photograph, that a very desirable feature, in a subway transformer, is obtained, that is, the floor space is reduced to a minimum by omitting the corrugations on the sides of the greatest dimension of the transformer proper, thus reducing the dimensions in this direction by the depth of the corrugation.

The circular flange at the top also provides a free space for the construction to connect the underground leads to the transformer inside of the tank, and furnishes also a chamber to allow for the expansion and contraction of the volume of air over the oil due to the variation in the temperature.



Method of Fastening Core and Coils in Tank 75 to 200 KW.

By means of a sling engaging with the lifting lugs cast on the cover, the transformer can readily be lowered into the manhole.

COMMERCIAL IMPORTANCE OF HEATING DEVICES TO THE CENTRAL STATION

By ERRETT L. CALLAHAN

The Central Station man has come to realize that the various electric heating devices when connected to his lines bring him most excellent profits, and it may seem strange that he has seemingly awakened to this fact only recently.

Circumstances have been against the wide distribution of heating devices, for the Central Station Manager has been occupied in extending his lines, and in increasing the capacity of his plant to take care of business that came to him practically unsolicited. He has finally placed his plant in a position to anticipate reasonable future demands, and has turned his attention to ways and means of getting new business—practically non-peak day load power and heating business.

All Sizes of
ELECTRIC MOTORS
Kept in Stock
SEE OUR
ELECTRIC
FLAT IRONS

Stock Room, Dallas Electric Light Company

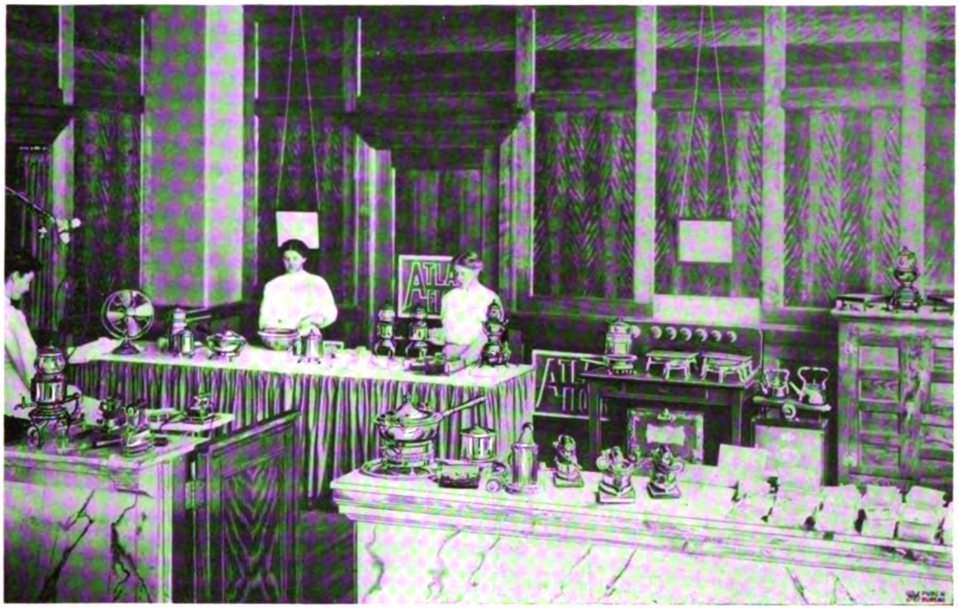
Organizing a Heating Department

Every Central Station should have a heating department whether the station be large or small. This department stands for *progress*, *public service* and *profits*, all three of which are necessary to the Company's welfare. Even though the plant be so small that but one solicitor is retained to bring in the business, a heating department should be recognized and receive as much earnest thought and have as much time spent for its welfare and growth as is given to the lighting department, for what is every one's business is no one's business.

A scrap book should be started to contain clippings of articles telling what other people and stations are doing, and to keep a record of various helpful publications, circular letters and advertisements. The solicitor should start a card file, which will be filled with information, gathered day by day, from his pocket note book, and added to, from time to time, by the contract department; thus, the result of each call, or communication from the prospect is recorded. Intelligent solicitation will tell every time.

Another card file under purely future business, suggested, from time to time, by observation or information, should be kept. The most effective "tickler" systems will suggest themselves.

There need be no change in rates, unless it seems advisable to make special power rates and provision for the installation of complete "cooking and baking outfits." The popular day load heating devices are so well adapted to use of the lighting circuit that the business can be obtained, usually, without increase of the present transformer or generating equipment. I have heard many Central Station men refer to the revenue received from electric irons as "all velvet."

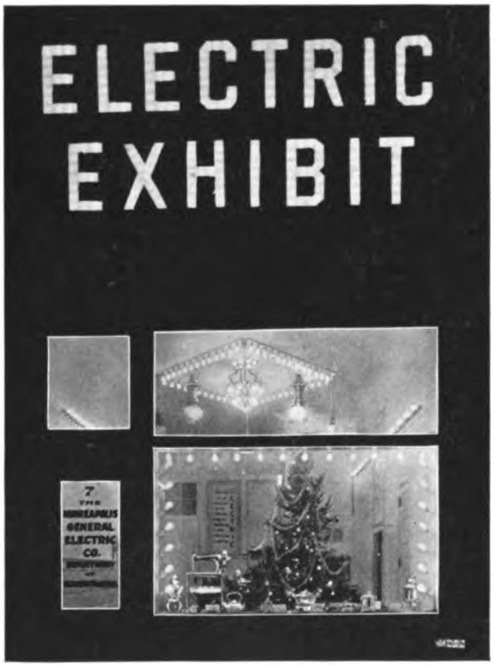


Demonstration Room, Milwaukie Illuminating and Lighting Company

Solicitors

The electric heating solicitor must be an enthusiast, and have a firm and thorough knowledge of the practicability and durability of the devices. He must be able to impart his confidence in the merits of the devices to the prospective purchaser, as, due to unfamiliarity in Electric matters, imaginary fears from electric shocks are even yet quite general in the feminine mind.

Several Central Stations have found young women solicitors very efficient indeed. It seems to me, that through young women solicitors, the house to house canvass can be made with excellent success in view of their particular fitness for demonstrating the devices. In St. Louis, nearly all of the electric flat irons in use were put out by young women solicitors and demonstrators. The successful heating solicitor will be on the lookout for opportunities for business at card parties, clubs, social gatherings of all kinds and in the sick room and home. The wide awake solicitor should have his calendar filled with engagements for the *chafing dish*, luminous radiator and coffee percolator. He will talk heating so constantly, pointing out the advantages to be gained by each one personally, that people will catch his enthusiasm and appreciate as he does, the convenience and efficiency of electric heating devices; to talk with him will give one the impression that he knows what he is talking about.



Show Window at Night, Milwaukie

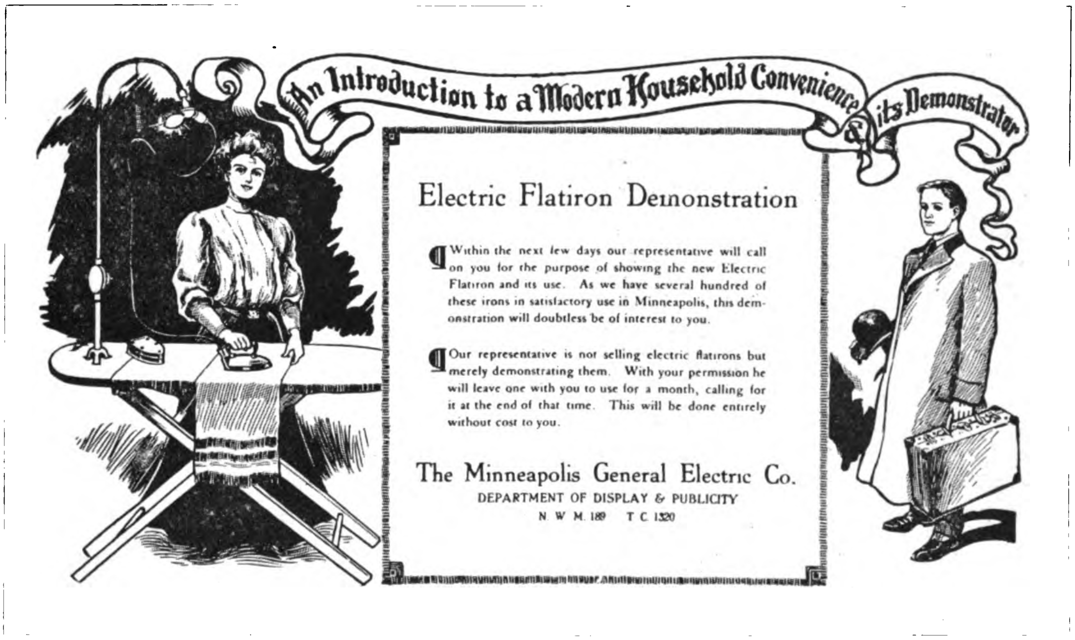
The solicitor should provide himself with a complete list of residences that are wired, whether connected to the service or not. These should be grouped in sections or by streets, in order to economize time in visiting prospects. .He should not trust to his memory, but should jot down points bearing upon future business at each call.

It is easy for a representative of the "Electric Light Co." to get an audience at each house, explain the object of his call, show, for instance, the simplicity of connecting and disconnecting a flat iron, and the advantages of its use after becoming hot in four minutes time.

Display

There should be an attractive show window exhibit to let people know that the "Electric Light Co." sells electric heating conveniences, and that it is anxious to serve the public. The exhibit loses its effectiveness unless it receives a little daily attention. I have seen show window exhibits so dusty and dirty that it was a relief to look across the street instead of at the conglomerate mass called a window exhibit. It costs very little to change a window display, and by so doing, people give it attention in order to miss nothing. Things in action attract the eye; therefore, boil water, operate the coffee percolator, the luminous radiator, or flash a different sign each day or evening. It can be done cheaply if a little ingenuity be used.

A large pile of flat irons or other devices impresses the public with the fact that the company is doing a good business — it looks prosperous and shows confidence in stocking up — if the pile does not melt fast enough each day, let a few be taken to the stock room until it is necessary to rebuild the pile.



An Introduction to a Modern Household Convenience & its Demonstrator

Electric Flatiron Demonstration

¶ Within the next few days our representative will call on you for the purpose of showing the new Electric Flatiron and its use. As we have several hundred of these irons in satisfactory use in Minneapolis, this demonstration will doubtless be of interest to you.

¶ Our representative is not selling electric flatirons but merely demonstrating them. With your permission he will leave one with you to use for a month, calling for it at the end of that time. This will be done entirely without cost to you.

The Minneapolis General Electric Co.
DEPARTMENT OF DISPLAY & PUBLICITY
N. W. M. 189 T. C. 1320

Card sent to prospective customers in advance of demonstrator

Every opportunity to exhibit and demonstrate heating devices before the public should be seized upon. Remember the most of us have to be *shown*, and there is a splendid opportunity for this in every domestic science school, pure food and other show, where the most sceptical can be convinced. If possible, a room for display and demonstration purposes, either in connection with the office or a separate store or "Electric Exhibit" is extremely valuable in pushing the sale of heating devices; and where space will permit, let there be arranged an up-to-date electric kitchen, bedroom and sitting room on a full sized scale, so that the usefulness of the devices will come closer home to customers as they visit the "electric home." The reader is referred to excellent equipments of this kind in John Wanamaker's stores in New York City and Philadelphia.

Several Central Station Managers have more or less elaborately equipped their own homes first, and have thus started the ball rolling by entertaining their friends. I think this is extremely effective and has done more toward starting the "Complete Electric Kitchen Equipment" business than anything else.

Distributing Electric Heating Devices on Trial

The electric flat iron has been called the "entering wedge" to the heating business, and the enormous quantities of irons sold in 1906, prove that the 30 to 60 day free trial proposition, extended to the public by nearly every Central Station, was a good one.

These irons have been successfully distributed in wagon loads without previous solicitation. House to house canvass by demonstrators has proven most successful, however, but in several instances, very flattering results have been obtained by mail solicitations with return postal card.

Other heating devices, not being so mechanically indestructible, are scarcely adapted for free trial, but, as pointed out above, the progressive Central Station man will set aside from his stock one or two devices of each kind for loaning on special occasions. Each loan of a device should bring a sale; each loan of a chafing dish at a party should, if followed up, sell from one to six; likewise with coffee percolator, water heaters, etc. The policy of renting flat irons has been agitated by several Central Stations and makes an attractive proposition to the customer, but in view of the very reasonable price at which Central Stations sell flat irons, and the extra bookkeeping necessary to keep the records, this method of distribution, I think, will not come into general favor.

Advertising

I have heard several Central Station men state that their good results in obtaining a large heating business, were secured by dividing their appropriation for heating advertising equally between newspaper advertising, personal solicitation and direct—by mail-advertising.

I have in mind other Central Stations where the greater proportion of the advertising was spent through personal solicitation and demonstration to most excellent advantage. My observation has been that the latter division is surer of results. I believe in specializing in advertising heating devices. For instance, make sure that during the months of January and February, every residence customer knows what a luminous radiator, electric corn popper, and a heating pad is, and where to get them or to see them operated. Whether or not this is done through the newspaper, matters little if followed up by personal solicitation.

Considerable favorable comment has been excited by the success met with in offering flat irons as premiums with newspaper subscriptions. In Spokane, Washington, more than 3000 irons were sold in this way last summer.

Class of Customers to Reach

In the earlier days, it was thought that the wealthy only would be induced to purchase electric heating devices. On the contrary, the large quantities of flat irons and other devices sold during 1906 did not go into wealthy homes but into the homes of people who are thoughtful of the comfort of their servants or where the mistress of the house does all or most of her own work.

The solicitor will find that this class of people gives him the most heating business for any device that will lessen labor, give more comfort and operate without inconvenience.

We have been considering domestic conveniences, but the solicitor should not lose sight of the large amount of heating business in the industrial field, which has scarcely been touched as yet.

Future of Heating Business

If you will but look with me into the future about five years, you will see that people are enjoying life more than they ever have, for now the housewife who used to fret herself into a fever because the cook "had given notice" or had abruptly left, is truly mistress of the house, for she is mistress of the wonderful electric current which at the turn of the switch, does her bidding and cooks the meal — and now, what if the cook does leave? There is a question whether she is wanted or needed at all. The motor driven washing machine, clothes wringer, electric drying machine and iron have been members of every home family circle, as it were, for three or four years.

Coming back to the present, as this may appear visionary, let us look at the field for flat irons alone: the population of the United States is about 84,000,000, or equivalent to about 15,800,000 families. We will estimate that 1,200,000 residences are wired for electricity (one in every fifteen). While it is true that it has taken about ten years for all of the heating companies to sell approximately 500,000 flat irons, at the present rate of manufacture and sale by the General Electric Company alone, 200,000 irons can be put out in five years. Let us assume that 50 per cent of the residences wired, buy one electric iron during the next five years, and that the increase in old and new residences having electric wiring is 50 per cent of the present number. This means that over one million irons, used on an average of five houses a week will, at 10 cents kw. hour, bring the Central Station a revenue of one million dollars a month. Is not the flat iron business worth working for?

Summary

Just now more than ever, Central Stations need profitable day loads to increase their balances on the right side of the ledger. They can get this business by starting and maintaining an efficient, aggressive and progressive heating department, for while heating devices are not essential to life, much missionary work must be done to teach the people how to get more comfort out of life by their use.

The flat iron is the natural leader to the heating business, and is fast becoming a household necessity. It is the best revenue getter for the Central Station — put it in use and it will prove an excellent solicitor for the purchase of other devices.

HUNTING OF ALTERNATORS

By ERNST J. BERG

I—Continued

In the preceding paper upon the "Parallel Operation of Alternators" in the January Review, Boucherot's formula for determining the natural period of alternators was given. This, while approximately correct, is not sufficient to determine the period under all conditions of operation, since it does not take into consideration the relative amounts of self induction and armature reaction in the alternator, nor the effects of wattless current, line resistance and reactance.

In the following paper, the formula which involves all these constants is deduced. It is, therefore, of considerable importance. The complete deductions of the formula are given, as they are instructive and have often been requested of the writer.

Since every alternator has a natural period of its own, it is evident that if this period happens to coincide with the engine period, resonance takes place, and parallel operating becomes difficult, if not impossible. It is, therefore, necessary to determine in each case these periods.

Since with a given load there is an actual displacement of the armature in space, (the magnetite of which depends upon the constants of the machine) we can compare the alternator to a material pendulum in which the torque at the periphery represents the restituting force, and the displacement is the phase displacement reduced to the periphery.

In discussing the compounding of alternators, we found an expression of the mechanical displacement of the armature with load—

$$\tan \Phi = \frac{m\,i + n_1}{m i_1 + n}$$

In an alternator of P poles the corresponding angle at the periphery is:

$$\tan \alpha = \tan \frac{\Phi}{\frac{P}{2}} = \frac{2 \tan \Phi}{P}$$

The torque at the periphery corresponding to the output is:

$$F = \frac{14100 \text{ Kw.}}{N D}$$

Where F is expressed in lbs.

D = diameter of armature in ft.

N = revolutions per minute.

For small angles $\tan \alpha = \frac{F}{p} = \frac{F}{ma}$

Thus $a = \frac{F}{m \tan \alpha} = \frac{F P}{2m \tan \Phi}$

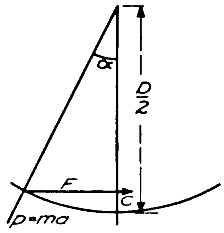
Where a is the acceleration corresponding to force F and mass m

But $\frac{N}{60} \times \frac{P}{2} = f =$ frequency.

Thus $\frac{P}{2} = \frac{60 f}{N}$

And $a = \frac{60 \times f \times F}{m N \tan \Phi}$

With force F, a mass m and an acceleration "a" we have $F = ma = m \frac{dv}{dt}$ where v is the velocity at time "t." If s is the distance traversed at time "t" we have $v = \frac{ds}{dt}$, therefore $F = m \frac{vdv}{ds}$, or $Fds = mvdv$



Integrating we get—

$$\int_{v_0}^{v} Fds = \left(\frac{1}{2} v^2 - \frac{1}{2} v_0^2\right) m \text{ where}$$

$\int Fds$ represent the work done by force F.

The work done can also be represented by the weight times the distance C in Fig.

$$C = \left(\frac{D}{2} - \frac{D}{2} \cos \alpha\right) = \frac{D}{2} (1 - \cos \alpha).$$

For rotary motion if ω is angular velocity we have $v = r \omega$

Thus —

$$\int Fds = p \frac{D}{2} (1 - \cos \alpha) = \tfrac{1}{2} mv^2$$

$$= \frac{1}{2} mr^2 \omega^2 = \tfrac{1}{2} \omega^2 J$$

When $J = mr^2$ and r = radius of gyration or $\frac{m a D}{2} (1 - \text{Cos}\, \alpha) = \tfrac{1}{2} \omega^2 J$ or $1 - \text{Cos}\, \alpha = \frac{\omega^2 J}{m a D}$

For a pendulum of length l and weight p we have by a similar reasoning—

$$\tfrac{1}{2} \omega^2 \frac{p}{g} l^2 = pl (1 - \text{Cos}\, \alpha)$$

$$\text{thus } \tfrac{1}{2} \omega^2 \frac{pl^2}{g\, pl} = \frac{\omega^2 J}{m a D}$$

$$\text{or } l = \frac{2 g J}{m a D}$$

But with a pendulum of length l the time of one oscillation

$$\text{is } T = 2\pi \sqrt{\frac{l}{g}} = 2\pi \sqrt{\frac{2g J}{maDg}} = 2\pi \sqrt{\frac{2J}{maD}}$$

Or if N_1 = period of natural beat, then

$$N_1 = \frac{60}{T} = \frac{30}{\pi} \times \sqrt{\frac{m a D}{2 J}}.$$

Substituting for a we get—

$$N_1 = \frac{30}{\pi} \sqrt{\frac{m D}{2 J} \times \frac{60 f F}{m N \tan \Phi}}$$

and finally substituting for F we get:

$$N_1 = \frac{30}{\pi} \sqrt{\frac{60 D f}{2 J N \tan \Phi} \times \frac{14100 \times \text{Kw.}}{N}} =$$

$$\frac{1130}{N} \sqrt{\frac{\text{Watts} \times f}{WR^2 \tan \Phi}} =$$

$$\frac{1130}{N} \sqrt{\frac{\text{Watts} \times f \times (mi_1 + n)}{WR^2 (mi + n_1)}}$$

Where—

N_1 = Natural period in beats per minute.
Watts = watt rating of generator.
W = weight of revolving elements in lbs.
R = radius of gyration in feet

$$\tan \Phi = \frac{m\,i + n}{m i_1 + n_1}$$

N = revolutions per minute.
f = frequency of generator.

$$\text{Where } m = \frac{\text{armature reaction}}{\text{full load current}}$$

n = no load AT from tangent of saturation curve at e corresponding to $e + ir + i\,x$
n_1 = AT from tan. of saturation curve (beginning at voltage e corresponding to $ix - i_1 r$.
i = full load energy current.
i_1 = wattless lagging current, or
$-i_1$ wattless leading current.

This equation shows among other things that:

In a generator, the higher the resistance between constant potential busbar and machine, the higher is the natural frequency.

The higher the reactance between constant potential busbar and machine the lower is the frequency with noninductive or lagging current.

Leading current gives lower frequency and lagging current higher frequency.

In a synchronous motor or rotary converter:

The higher the resistance between generator and converter, the lower frequency. With lagging current, the higher reactance the lower frequency. With leading current, the higher reactance the higher frequency. This, due to the fact that the impressed voltage is lower as we increase the resistance and as we increase the reactance with lagging current.

The effect of leading current in the synchronous motor or converter is opposite to that in the generator, since in a generator, the lagging current demagnetizes, whereas, in the motor, it magnetizes. Therefore, in a motor or rotary with lagging current, the period is longer.

The fact that the period can be changed very considerably by change of field excitation in generators, as well as motors or rotaries; the further fact that the line resistance and reactance materially effect the period, show that where hunting is taking place and the hunting is due to the co-incidence of the natural period of the electric unit and the prime mover, it should be possible to stop it in almost every case without redesign.

It might be asked, what prevents the machines dropping out of phase when hunting is taking place?

In a smooth rotor machine with uniform self-inductance in every position, the amplitude might increase with each beat, and can only be limited by external load, such as eddies set up in polar windings.

In the definite pole type of machine where the magnetic reluctance is different in different positions, the natural period changes with the position of the armature, thus in one positon, it tends to beat at one rate, and in another position, at a different rate, while at extreme positions, the rate is so different that the effect is not cumulative.

To sum up; hunting, although very interesting from the electrical engineering point of view, will, in 99 cases out of 100, be traced to the prime mover.

Among the many hundred direct connected units in operation, hardly one case has been met with where the difficulty was not due to the governor of the engine. As a rule, satisfactory operation is obtained by improving the governor dash pot. In some cases, however, an entirely new design or governor is necessary.

LINE CONSTANTS AND ABNORMAL VOLTAGES AND CURRENTS IN HIGH POTENTIAL TRANSMISSIONS

II

ERNST J. BERG

With a large number of the very high voltage transmission systems being planned at present, the information readily available in regard to capacity, inductance, etc. of transmission lines, is not sufficient to pass upon some of the important questions which necessarily will be brought up. Below are given, therefore, the equations from which these constants can be determined.

$$L = \frac{161}{10^3}\left[2\ {}^{n}\lg\frac{2D}{d} + \frac{1}{2}\right]$$

where L is inductance per mile of wire (single phase or three-phase) expressed in Mil-henrys.

D is the distance between centre of wires.

d is the diameter of wire in same unit as D.

The capacity between one wire and neutral, whether single or three-phase circuit, is:

$$C = \frac{890\ k}{10^4\ {}^{n}\lg\frac{2D}{d}} = \frac{386\ k}{10^4\ {}^{10}\log\frac{2D}{d}}$$

Where C is expressed in micro-farads per mile of wire against neutral, D and d in same units as before. k is the specific inductive capacity which for air is one.

Neglecting the quantity ½ inside the parenthesis in the inductance formula, which is permissible if the distance between the wires is large compared with their diameter, we get—

$$L = \frac{742\ {}^{10}\log\frac{2D}{d}}{10^3}$$

$$C = \frac{386\ k}{10^4\ {}^{10}\log\frac{2D}{d}}$$

We see at once that the product of inductance and capacity is constant, regardless of distance between wires or their diameters;

$$\text{or } L\ C = \frac{286}{10^4}$$

where L is expressed in mil henrys, and C in m.f., both referring to one mile of wire;

$$\text{or } L_1C_1 = \frac{286}{10^{13}}$$

If L_1 and C_1 are expressed in henrys and farads; therefore if M = number of miles of wire, we get:

$$L'_1C'_1 = \frac{286\ M^2}{10^{13}}$$

Where L'_1 and C'_1 are the total inductances and capacities of each wire in the system.

The natural period, that;is the frequency at which the system oscillates due to its own constants, depends only upon the inductance and capacity, as long as the resistance is reasonably low so that oscillation can occur.

With concentrated inductance and capacity, it is expressed as $f = \frac{1}{2\pi\sqrt{LC}}$

With distributed capacity, Steinmetz has shown that the frequency is expressed by $\frac{1}{4\sqrt{LC}}$ where L and C are given in henrys and farads.

Since, as shown above, the product L C is independent of distances of conductors or their size, it is therefore evident that the natural frequency is also independent of these constants and depends only upon the distance of transmission.

Generally, when discussing the natural frequency of a line, we mean the frequency which the line would have if charged above the ground potential by atmospheric influence and suddenly relieved of the charge. In this case we should consider the inductance and capacity against ground. These are found by the following equations:

$$L_0 = \frac{2 \times 161000\ M}{10^9}\ {}^{n}\lg \frac{4D}{d}$$

$$C_0 = \frac{178000\ M}{2 \times {}^{n}\lg \frac{4D}{d}\ 10^{12}}$$

Where L_0 and C_0 are given in milhenrys and farads.

M is number of miles of wire.
D is distance of conductor above ground.
d is diameter of conductor.

The frequency so obtained is, of course, the same as when using the inductance and capacity between wires.

A ready way to determine the natural frequency of the line, is to calculate it from the fact that the length of the line constitutes one-quarter of the wave, so that, since the velocity of electrical propogation is the same as that of light, the frequency, for instance, for a line 150 miles long, is:

$$\frac{187000}{4 \times 150} = 312 \text{ cycles.}$$

It is, of course, important that the fundamental frequency, or that of any prominent harmonic, shall not be the same as the natural period of the line, since, when that is the case, destructive resonance phenomena are likely to happen.

It has hardly been appreciated that, of the higher harmonics, the 3rd cannot exist in a three-phase line, although it is the most prominent in the generator.

(Unless Y Y connection of transformers is used, which is not good engineering. But even in that case the triple harmonic appears only in the potential against ground, never in the voltage between the lines).

We need, therefore, consider the fifth harmonic more particularly so for instance, in a line 150 miles long, the frequency of the fifth harmonic is obviously five times that of the fundamental. Consequently, in a 60 cycle circuit we have 300 cycles, which is very closely the same as the natural period of the line. 60 cycles would therefore not be feasible unless the line was artificially loaded.

It is perhaps opportune to give an average value of inductance and capacity in high potential lines. By assuming the inductance as 1.75 mil-henrys per mile of wire, and a capacity of 0.0165 m. f. per mile of wire, an error of more than 15% cannot well be made, when referring to transmissions of from 30,000 to 100,000 volts, and conductors from ¼ in. to 1 in. in diameter.

Since, furthermore, in these high potential lines it is always necessary to have at least two lines in parallel, it is well to bear in mind that in doing so ohmic drop is the same, whereas the inductive drop is one-half and the charging current is twice as large as with one line. The reactance corresponding to certain inductance is expressed by the following formula:

The reactance $x = \frac{2\pi\ n\ L}{10^3}$

The charging current I_0 is expressed by the following formula: $I_0 = \frac{2\pi\ n\ C\ E}{10^6}$

Where n is the frequency
L is the inductance in m.h.
C is the capacity in m.f. and
E is the voltage to neutral plain.

If L and C correspond to mile of wire, x and I_0 obviously also refer to the same.

It is interesting to note in connection with this, that since the voltage to the neutral in a single-phase system is one half, and in a three-phase system = 0.58 of the line voltage; the charging current per wire for a given line voltage is 16% greater in a three-phase system than in a single phase system.

With the help of these constants, we can now readily calculate some of the abnormal phenomena.

1st Abnormal Voltage and Current in Opening or Closing a Circuit

To determine this it is necessary to calculate the stored energy. The energy in joules (watt records) stored electromagnetically is 1/2 $L I^2$. The energy in joules stored electrostatically is 1/2 $C E^2$. Where L and C are given in henrys and farads.

Therefore, if the line is disconnected at the moment the current has a given value i, energy is stored which must be spent some way. The only path for the current is formed by the line capacity, therefore the line becomes charged to a certain voltage depending upon its constant, next it discharges through the inductance of the line, so charges again, etc. A current oscillates in the system until the energy is dissipated by the resistance of the line. Therefore, with low resistance, there will be many surges, with high resistance, few.

The two energy equations become:

$$\tfrac{1}{2} L I^2 = \tfrac{1}{2} C E^2 \text{ thus } E = I \sqrt{\frac{L}{C}}$$

or $I = E \sqrt{\frac{C}{L}}$ Substituting the average values given above we get

$$E = 325 \text{ I and } I = \frac{E}{325}$$

We see from this that the E. M. F. induced on opening a circuit is independent of the length of the line.

Opening a Switch at Full Load Instantaneuous Value of Current

In a 60.000 volt transmission of 20,000 kw. the rise will be 60.000 volts per phase; consequently the total voltage will be almost trebled. Interrupting charging current will, however, give very low rise, since the current then is small, so that there is no difficulty to be anticipated by disconnecting such line.

But, in connecting the line the moment the E. M. F. is maximum, *a very considerable instantaneous current will flow*, namely $\frac{E}{325}$ Consequently, with a voltage between the lines of 60,000, when the voltage per phase is 34,700, the current would be about 100 amperes; whereas, the charging current probably is about 10 amperes.

It is also evident from this that we must use such circuit interrupting devices as open when the current is small, preferably zero. From a great number of oscillograms we have found that our oil switches break at zero value of current, and we find that no rise in voltage will occur when they are used.

Indeed, from some oscillograms that have been made in which the circuit has been opened by air switches, it would seem as if, when the line voltage is sufficiently high, the arc will keep on until the current value is decreased to such a small amount that, at the time of break, there is no serious rise in voltage. A gust of wind might, however, cause the circuit to be broken when the current is large, when, of course, a rise would take place.

It is also interesting to note that, since the rise in voltage is independent of the line voltage, we are likely to have relatively worse stresses with low voltage systems; although, to be sure, if the voltage is sufficiently low, the likelihood of the current being interrupted at any point but the zero point is slight.

These phenomena of large currents and high voltages in a line, apply to grounded as well as not grounded systems.

2nd. Abnormal Currents and Voltage Stresses in Connecting a Transformer to a System

Outside of the ordinary stresses between adjacent turns, and winding against ground, there is a very high potential stress between the first few turns of the primary winding, when the transformer is connected to a live line. The very first instant that connection is made, one part of the winding is raised at line potential, whereas the rest of the winding is still at ground potential. Consequently, the full voltage exists between the first turns. It is therefore necessary to insulate the first few turns extremely well as compared with the succeeding turns.

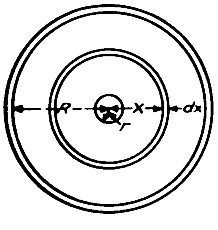
It is also evident that, when being thrown on the line, the transformer may sometimes take a much *larger current than the normal exciting current.* If the transformer when last used was disconnected from the circuit when the flux was at its maximum value, the density will decrease after a short time to about 70% of the maximum value, as can be seen by studying the hysteresis loop. If now the transformer is connected to the circuit at such a point of the potential wave as requires increasing flux, the magnetizing current must be very large, since the iron is already at 70% of the saturation point. At the next instant, however, the magnetic condition will adjust itself, so that the current is normal. The first large current is, of course, of very short duration, but might well be 20 times the exciting current or 2 or 3 times full load.

3rd. Abnormal Voltage in a Not Grounded System

There has been a great deal of discussion about grounding or not grounding the neutral of transmission lines. For the very high voltages considered at present time, I doubt very much if anything but a grounded system can be considered.

When operating at such very high voltages, the difficulties of protecting a transmission, and indeed of building and installing the apparatus, increases very materially. In the wiring and line itself, a minimum size of conductor, which already is quite large, is necessary in order to prevent corona effects. This corona involves loss in power and is a likely producer of nitric acid, which is detrimental to adjacent insulation.

Investigation of Corona Effects in Parallel Conductors



Let I = current flowing in conductor.

MMF per unit length in zone $= \frac{I}{2\pi x}$

field intensity $= 4\pi \times \text{MMF} = \frac{4\pi I}{2\pi x} = \frac{2 I}{x}$

and Magnetic flux in the zone $= \frac{2I}{x} \times 1 \times dx$

thus total magnetic flux betweeen wire and zone $= \int_r^R 2I\,1 \frac{dx}{x} = 2I\,1\ {}^{n}\lg \frac{R}{r}$

neglecting flux inside of wire.

thus $L = \frac{\text{flux}}{I} = \frac{2\ 1}{10^9}\ {}^{n}\lg \frac{R}{r}$ henrys.

Therefore we can write the E. M. F. corresponding to this flux $E = k\ {}^{n}\lg \frac{R}{r}$

The flux between x and R is

$$L_x = 2\ 1\ {}^{n}\lg \frac{R}{x}$$

and corresponding E. M. F.

$$E_x = k\ {}^{n}\lg \frac{R}{x}$$

$$\text{therefore,} \quad \frac{E_x}{E} = \frac{{}^{n}\lg \frac{R}{x}}{{}^{n}\lg \frac{R}{r}}$$

The potential gradient is

$$\frac{dEx}{dx} = \frac{1}{x} \frac{E}{{}^{n}\lg \frac{R}{r}}$$

Therefore the potential gradient at the surface of the conductor is $S = \frac{E}{r\ {}^{n}\lg \frac{R}{r}}$ and at the inside of the outside sphere representing ground potential:

$$S_1 = \frac{E}{R \,_n\lg \frac{R}{r}}$$

The stress is therefore as much greater at the conductor than at the shell as R is larger than r.

Obviously, when applying this to parallel conductors, we should use as R, one half the distance between conductors, and as E, the voltage to neutral.

From a number of experiments, it looks as if the maximum stress that can be permitted in air is 100,000 volts per inch. Thus S = 100,000.

Based upon this value we obtain the following voltages of corona:

		No. 10 B&S	**No. 4 B&S**	**No. 000**		
		r=0.05 in.	r=0.10 in.	r=0.20 in.	r=0.5 in.	r=1 in.
R		E	E	E	E	E
5	in.	23000	39000	64000	115000	161000
10	in.	26500	46000	78000	150000	230000
20	in.	30000	53000	92000	184000	300000
50	in.	34500	62000	110000	230000	390000
100	in.	39000	69000	124000	264000	460000
500	in.	46000	85000	156000	345000	620000

We see, for instance, that in a 60,000 volt not grounded system, where the potential to ground can readily be 64,000 volts, the smallest wire that could be used in carrying the line through a wall having a hole 10 in. diameter is No. 000 B&S. Any smaller wire would give corona effects. No. 4 B&S would, at the same voltage, require a hole of about 100 in. diameter.

It is also evident that if, as often is the case, the high potential busbars are carried in compartments within but a few inches of ground, we must expect corona effects, especially so where there is a sharp bend in the wires, whenever for some reason the voltage is increased above normal. Incidentally we see the desirability of using large round busbars instead of small rectangular bars.

The dielectric strength of insulating materials is greater than that of air, so for instance, from a number of experiments, it seems that insulation of strips of rubber has a strength of about 350,000 volts per inch; oil of about 200,000 volts per inch; and varnished linen or paper, between 250,000 and 300,000 volts per inch. It is evident from this that we cannot subject this insulation to higher stress than this without causing deterioration. In the following table is calculated how much insulation is necessary with various sizes of wires and materials of various dielectric strengths.

Thickness of Insulation in Inches with Various Stresses at Surface of Conductor

500,000 VOLTS TO GROUND.

r	S=70,000	S=140,000	S=200,000	S=350,000
.05	5×10^{59}	5×10^{28}	2506×10^{16}	1256×10^{6}
.10	1×10^{29}	3163×10^{10}	708×10^{6}	158500
.20	6325×10^{10}	1125×10^{3}	53220	251.6
.50	792400	628.9	73.46	8.189
1.00	1258	34.49	11.16	3.169

300,000 VOLTS TO GROUND.

r	S=70,000	S=140,000	S=200,000	S=350,000
.05	7925×10^{31}	1991×10^{13}	5236×10^{7}	1377000
.10	3981×10^{12}	1995×10^{4}	322500	324.8
.20	3991×10^{4}	8934	3598	14.29
.50	2623.5	35.72	9.7	2.273
1.00	71.45	7.512	3.478	1.355

150,000 VOLTS TO GROUND.

r	S=70,000	S=140,000	S=200,000	S=350,000
.05	1991×10^{13}	9976000	161800	262.4
.10	1995×10^{4}	4666	179.8	7.1444
.20	8934	42.07	8.283	1.502
.50	35.72	3.755	1.739	.677
1.00	7.512	1.918	1.112	.535

60,000 VOLTS TO GROUND.

r	S=70,000	S=140,000	S=200,000	S=350,000
.05	1380000	263	20.04	1.488
.10	325	7.15	1.904	.4546
.20	14.3	1.5	.6954	.271
.50	2.28	.68	.4108	.2043
1.00	1.35	.54	.35	.187

30,000 VOLTS TO GROUND.

r	S=70,000	S=140,000	S=200,000	S=350,000
.05	263	3.6	.9525	.2273
.10	7.15	.752	.34477	.1355
.20	1.5	.384	.2232	.1041
.50	.68	.27	.1748	.0934
1.00	.54	.24	.162	.09

15,000 VOLTS TO GROUND.

r	S=70,000	S=140,000	S=200,000	S=350,000
.05	3.6	.37		
.10	.752	.192		
.20	.384	.14		
.50	.27	.12		
1.00	.24	.11		

It is interesting to see that, even with rubber insulation, we should insulate a wire of 1 in. diameter with about 8 in. of insulation if subjected to 500,000 volts potential to ground.

At 300,000 volts we should need 2.27 in. of insulation.

At 150,000 volts we should need 0.68 in. of insulation.

At 60,000 volts we should need 0.20 in. of insulation.

This would give no safety factor whatever. At 500,000 volts the smallest wire than can be insulated is about 1 in. in diameter. At 300,000 volts, ½ in. in diameter; at 150,000 volts, 0.20 in. diameter; and 60,000 volts, a very small wire.

But limiting the stress to 140,000 volts per inch we find that:

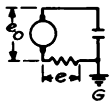
For 500,000 volts the wire should be more than 2 in. in diam.
300,000 volts the wire should be about 2 in.
150,000 volts the wire should be just a little less than 1 in.
60,000 volts the wire should be .20 in. No. 000 B&S.
30,000 volts the wire should be .10 in. or No. 10 B&S.

It is evident from this that it is very essential to keep the maximum voltage down when considering voltages around from 60,000 to 100,000 volts. By grounding the neutral we limit this to 58% of the voltage between lines.

Apparent Erratic Voltage Between Terminal and Ground

When measuring the voltage between any of the terminals and ground, it is observed that it is not definite, but depends, essentially, upon the resistance in the circuit. This, however, is natural, as can be seen from the following reasoning:

Let e be the voltage from terminal to ground, that is, the voltage across the resistance,



e_0 be the generator voltage per phase,
x = capacity reactance of the system,
r = the resistance between the capacity and the terminal.

We have then:

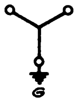
$$\text{current flowing} = \frac{e_0}{r + jx}$$

and voltage across the resistance:

$$e = \frac{e_0\, r}{r - jx} = \frac{e_0\, r}{\sqrt{r^2 + x^2}}$$

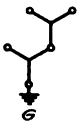
With a generator disconnected from any line, the charging current against ground is, of course, very slight. So that x is very large, therefore for moderate values of r, compared with the values of x, we see that changing the resistance does not materially change the denominator, but the voltage e is proportional to the resistance; thus there is a constant current effect. The more resistance is put in circuit the higher is the voltage. With infinite resistance the voltage is

$$\frac{e_0}{\sqrt{3}} = 0.58\, e_0$$



Effect of Slight Leaks in Switches, etc.

Assume, next, that the terminal of one phase through a slight leak is connected to ground; the voltage between the other phases and ground will then be almost doubled, being e $\sqrt{3}$



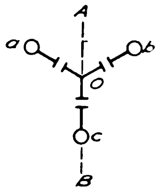
If there are two sets of generators running independently, and there is a slight leak from one terminal of one to that of the other, and also a slight leak to ground, there will be at times 3½ times as great potential to ground as when the neutral is grounded. This condition might well occur when synchronizing machines or transformers. In circuits of moderate voltage, these voltages might not cause undue stresses, but with a normal voltage of 100,000 it is quite different.

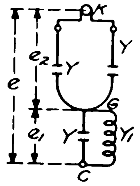
But grounding a terminal does not always give the same results. A positive "*good*" *ground does not cause the "statics" of an arcing ground.* The reason is as follows: No matter how or where the circuit is made, as long as there is an arc, there is a circuit. Usually this contains resistance, reactance and capacity.

With a positive ground, the frequency impressed is that of the generator, and it would be but a chance if the values of capacity and reactance should be such as to cause more than slight resonance. With an arcing ground, on the contrary, the circuit is disconnected, and can, and will, oscillate at its own frequency, which is such as to give resonance, which means such as to give the maximum voltage and current.

To be sure, if as in our lightning arrester the oscillations are damped out by judicious use of resistance, no dangerous voltages occur, but with accidental slight leaks or grounds, it is quite different. The voltages from ground might then be almost anything. Some protection is, of course, to limit the rise by grounded neutral.

In a not grounded system, grave danger exists under almost all conditions of disturbed service. For instance; a lightning stroke disables some apparatus so that inductance is introduced in the accidental ground. Before the accident we had a perfectly balanced system, where the neutral, or ground potential, is symmetrical in reference to the line conductors, and governed entirely by the ground capacities represented in figure as three condensers. If now one line is grounded by an impedance, the neutral will be displaced along line A - B.





For convenience in demonstrating, we can change the diagram to a single phase system, making due allowance, however, in the final conclusions — we will reconstruct the system to another shown in Figure.

Let Y represent the admittance of each condenser, Y_1 the admittance of the impedance connected to ground, which is electrostatically the same as connecting impedance between the line and the point of neutral potential.

We have then the joint admittance between C and G = $Y + Y_1$, therefore the joint impedance $\frac{1}{Y + Y_1}$. The joint admittance between G and K is 2Y, therefore the corresponding impedance is $\frac{1}{2Y}$. The total impedance is therefore:

$$\frac{1}{Y + Y_1} + \frac{1}{2Y} = \frac{3Y + Y_1}{2Y\,(Y + Y_1)}$$

The current is therefore, $\frac{2eY\,(Y + Y_1)}{3Y + Y_1}$

$$E_1 = \frac{2EY\,(Y + Y_1)}{3Y + Y_1}\ \frac{1}{Y + Y_1} = \frac{2e\ Y}{3Y + Y}.$$

$$E_2 = \frac{2eY\ (Y + Y_1)}{3Y + Y_1} \quad \frac{1}{2Y} = \frac{e\ (Y + Y_1)}{3Y + Y_1}$$

$Y = g - jb$ where g is energy component of current

b is wattless component of current in the condenser.

$Y_1 = \frac{r}{Z^2} + \frac{jx}{Z^2}$ where r is energy component of E. M. F. and x is wattless component of E. M. F.

We will assume that there is no leakage in the line, therefore $g = 0$ and $Y = -jb$.

We will also assume that there is no resistance, but only reactance in the accidental ground of the line.

Thus $r = 0$ and $Y_1 = j\frac{1}{x}$

We get then $e_1 = \frac{2be}{3b - \frac{1}{x}}$ and $e_2 = \frac{\frac{1}{x} - b}{\frac{1}{x} - 3b}\, e$

If x_1 = condenser reactance then:

$e_1 = \frac{2ex}{3x - x_1}$ and $e_2 = \frac{x_1 - x}{x_1 - 3x}\, e$

1st. Ground made by infinite reactance. (No ground).

We have then $x = \infty$, $e_1 = \frac{2e}{3}$ and $e_2 = \frac{e}{3}$

Therefore in our diagram, the neutral lies at O, and the ground is symmetrical in reference to the three lines.

2nd. $\frac{1}{x} = b$, thus $e_2 = 0$, and $e_1 = e$.

In this case the neutral lies midways between the two other conductors, and 0.870 from the grounded line.

3rd. For $\frac{1}{x} = 3b$ e_1 and e_2 both become infinite showing that, under such condition, the system would be subjected to infinite potential.

b is the susceptance of the condenser, therefore $\frac{1}{b}$ is the condensance or capacity reactance. We see therefore, if one line is grounded by a reactance of 1/3 the condenser reactance, the system is subjected to infinite stresses, even at normal frequency. Energy losses limit the value considerably, however.

We might, for instance, in such accident have the line conductors 3 ft. apart and separated by 6 ft. from any wall, and still, upon inspection, find that each line was connected through flames to the wall, but that there was no flame between conductors.

Obviously, if the impedance had been grounded through an arc, high voltages would have resulted, almost independent of the relation between capacity and inductance. The remedy, in that case, would have been – grounded neutral.

Static Stresses of Generator and Transformer Windings Introduced by Accidental Ground

A ground might well cause serious break downs by the static effect only. Consider for simplicity's sake a single phase system, consisting of a generator, a transformer and a line.

There is, of course, a certain capacity between primary and secondary of the transformer winding. There is also a certain capacity between generator winding and the frame, which is the ground.

With the two lines symmetrical and well insulated, there is a balanced capacity against ground, thus the high potential coils of the transformer are at ground potential, consequently, the low potential coils and the armature windings are also at ground potential. If now one line becomes grounded, the potential of the coil against the ground is obviously ½ of the line voltage. Consequently, the low potential winding acting as the other plate of the condenser, is also charged to a certain potential, the magnitude of which depends upon the relative capacity of the generator winding to ground and the capacity between the transformer windings. If they are the same, then ½ of the line voltage is divided equally between the primary and secondary of the transformer and the generator winding to ground.

If the capacity between transformer coils is twice that of the generator winding against ground, then the generator winding will be subjected to $\frac{2}{3} \times \frac{1}{2}$ or $\frac{1}{3}$ of the line potential.

We can readily see from this how, when a ground occurs, the generator might possibly break down, and how in such cases it is important to get at all facts.

The remedy is a system with grounded neutral.

How to Ground the Neutral

Must we ground the neutral perfectly, or can we use resistance or reactance?

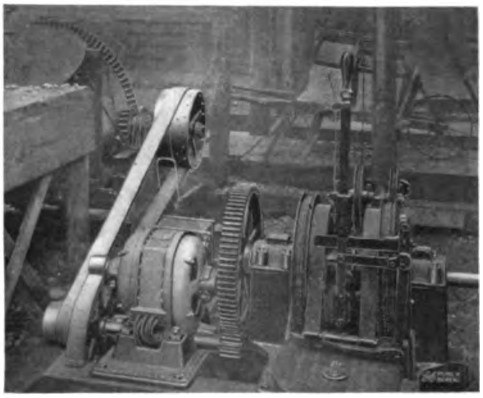
Without going further into the question, it is evident from the preceeding instance, that a reactance in the ground connection is not advisable; there are, indeed, several good reasons, but resistance needs some further discussion.

In moderate voltage systems — say up to 15,000 or 30,000, perhaps even higher, resistance is feasible, since under normal operation, the stresses are those of a grounded system. When, however, one line is grounded and the current is limited by this resistance, its function as a neutral ceases, and, as far as voltage stresses are concerned, the system might as well not be grounded. It saves, however, a shut down and permits the systems being rearranged without interruption of service. For transmissions of very high voltage I believe, however, that a good solid ground is best. Since any considerable rise might strain the insulation above its safe limit.

TRUXAL PAINTER HOIST

By FRED M. KIMBALL

The Truxal Painter Hoist shown below is driven by a General Electric 3 h.p., 220 volt, single-phase motor. In addition to the hoist, the motor operates a concrete mixer. With this latter fully charged, and the hoist raising a load of 350 lbs.. which is equivalent to 33 1/3 per cent over load. the motor draws 20 amperes. Under ordinary conditions, however, the concrete mixer and elevator are not operated together, and when they occasionally are, the work is intermittent.



Motor Driven Hoist

Equipments of this description can be used to great advantage by contractors, as they do not tie up much capital, and are very flexible in their application. They can be installed in the building where they are to be used and moved from floor to floor as the building progresses, thus avoiding long tail ropes and keeping the operator closely in touch with the workmen, so that their wants can be easily ascertained and met.

If the possibilities of motor driven hoists and concrete mixers were better understood by contractors, they would always use them where electricity is available, in place of donkey engine.

SOME CHEMICAL ASPECTS OF ELECTROLYSIS OF BURIED IRON STRUCTURES

By C. T. WILKINSON

The subject of electrolysis by earth returns in traction work continues to excite considerable attention, both in Europe and America. Perhaps, therefore, the following notes may be of interest to those who have to face the difficulty of determining whether or no various signs of pitting and corrosion of buried iron pipe, etc., are due to electrolytic action, or to the natural action of the earth's salts in the presence of water containing air.

Investigations relating to these results were undertaken some time ago by the writer, in conjunction with Herr J. D. Griffin, now of the A. E. G. of Berlin, and were undertaken for the help of expert witnesses in some of the litigation cases raised in London, England, at the commencement of the present active campaign in street railroad work in that city.

Determination of the Nature of Corrosion

Experiments extending over long periods, in which currents were caused to flow between pipes, plates, etc., buried in the earth were undertaken. The current densities and potentials between these structures were maintained under conditions which had been determined to be correct from actual observation in the city. They showed that one unfailing test was afforded by the color of the salt of iron formed by the corrosive action. Thus, in all cases where pitting and corrosion are due to the action of the earth with its own moisture, and the small amount of contained air, or oxygen. Examination of the pits and marks on the surface of the iron shows the presence of the red oxide of iron, with traces of various brown and yellowish sub-salts.

Where, however, the action is due to the flow of electric current from the surface of the metal, the salts produced are dense black in color, and apparently similar in nature and chemical composition to the black magnetic oxide of iron.

During the tests, it was observed that where this latter salt was obtained by electrolytic means and in the presence of excess of water, it first appeared as a dark rich green salt, changing, however, to the dense black salt above referred to after a few hours exposure to the light.

During the series of investigations above referred to, this test was found unfailing and a case occurs to mind where the writer found this information of great value in a dispute between the Water Company and the Traction Company in a New England town. An examination of a small 2 in. pipe from a certain district had shown this black deposit. The pipe was unburied, disconnected, and an ammeter inserted at the broken joint showed a flow of current of 14 amperes, which at the point where it left the pipe was producing most serious pitting.

Rapidity of Destructive Action

A rough rule of considerable interest, for those interested in this work, is to recall that theoretically one ampere flowing from an iron electrode continuously for one week will deteriorate one cubic inch of iron. This rule requires a reducing constant from 0.3 to 1.0, depending on the nature and character of the iron (See later note).

A Chemical Method of Prevention

The electro chemical consideration of this problem contains yet another point of exceptional interest. The destructive action is due solely and entirely to the presence of the chemical salts contained in the soil, their order of action being as follows: chlorides, nitrates, sulphates and carbonates, when considering iron electrodes. Hence, if these acid salts can be neutralized by chemical means, all destructive action must cease.

Experiments were, therefore, undertaken with the cheapest alkali, conveniently obtainable, namely, building lime, and careful tests then made appeared to fully bear out this supposition.

Clean, new iron plates, having their surfaces protected by a deposit of lime about one-half inch thick, were buried in earth, which was rendered very active by the addition of an extra quantity of salts and a current was allowed to flow through the circuit for some days, in series with a plate buried unprotected in the usual way. The results show that, while excessive action occurred on the unprotected plate, the protected plate showed absolutely no signs of corrosive action, the surface being as clean and fresh as when first buried.

The application of this principle in practice is perhaps only one use where the destructive action is limited to a small radius. In these cases, the pipe should be uncovered and examined, and, if found necessary, replaced by a new one. Before, however, filling the hole with earth, a layer of lime (preferably unslacked) should be placed on the surface, the depth varying to suit different conditions, and the earth then filled in in the usual way. The action is then as follows: Rain water percolating slowly through the soil from the surface, when it reaches the lime contains in solution some or all of the salts above mentioned. These, however, are rapidly neutralized and all danger is prevented.

An additional precaution to enable the lime to retain its strength for longer periods is to place pieces of wood, or other roofing, above the lime before replacing the earth, this roofing being arranged on an incline, in order that the majority of the water may drain off to the other side of the pipe or buried iron structure.

This scheme has been recommended in some cases, but no data is yet to hand covering a sufficiently extended period to be of value, though no reason for any but satisfactory results can be anticipated.

Protection by Use of Clay

The method of protection by the use of clay is also of interest. In this method, when the iron pipe is laid under the ground it is covered with a layer of puddled clay, the coating being a few inches thick. The action of this device is as follows: Clay itself serves as a screen, similar to the wood screen referred to, which may be used in connection with the application of lime, and in general if placed on the pipe thoroughly wet and well puddled will give considerable satisfaction, it serves to prevent the salty solution from reaching the surface of the pipe.

The Nature of Iron

A point frequently overlooked is the effect of the nature of the iron pipes used. It was first brought to the attention of the investigators by occasionally meeting references in the technical papers to the entire absence of corrosion with cast iron pipes. Knowing, however, that in many cases cast iron pipes are more easily corroded than wrought iron pipes, further inquiry showed the pipes which seemed to be immune from these troubles were made of what is known as "white" cast iron.

The factors effecting the corrosion of iron and steel pipes for a given flow of current are very varying, depending on their nature. Thus, the corrosion of certain types of steel was found to be 80 per cent of the theoretical value for the formation of Ferrous salts, while that of some types of white cast iron was only about 30 per cent of the theoretical value. In other cases, however, with different characters of cast iron, the corrosion was practically 100 per cent of the theoretical value. These tests were made with fairly high pressures, that is to say in the neighborhood of 18 or 20 volts, while, if the voltage had been very low, in the neighborhood of 1 volt, tests made by Mons. Claude of the French Thomson Houston Co., showed that this action might become still less than that calculated from the above constants.

Apparent Inapplicability of Ohm's Law

No tests on electrolysis, with a view to obtaining practical results, should be made without careful consideration of the chemical side, since investigation shows that the electrolytic action has a noticeable effect on the apparent resistance. For example. two lengths of 2 in. gas pipe, each 60 ft. long, buried about two feet deep and 2 in. apart, were so connected as to make one the positive and the other the negative terminal, and the following results were obtained:

P. D. Between Pipes	Current in Amperes	Apparent Resistance
1	.03	33.3 ohms
2	.14	14.3 ohms
3	.32	9.4 ohms
4	.58	6.9 ohms
5	.80	6.8 ohms

It is, therefore, important to remember that when one observation of a current flow in a given pipe line parallel to a track has been made and the potential difference between the track and pipe noted at a given point, we are not justified in assuming that a variation in potential between the rail and pipe will cause a corresponding change in current. This is one of the most difficult factors which enter into the problems confronted when undertaking to examine a system where electrolytic trouble is said to be taking place.

A Few Points to be Held in Mind

The following points are of importance and should be kept in mind in districts where electrolysis is feared:

1—High conductivity of the rails and efficient bonding.

2—Drop in volts along the rails should be kept as low as possible.

3—The resistance of the track, on which the rails are laid, should be preferably high.

4—If possible, the conductivity of all the pipe joints where trouble is anticipated should be made as uniform as possible. This will result in a uniform distribution of electrolytic action over several miles of pipe, so that even though the total action which takes place might be considerable, it is spread over such a large surface that it becomes practically imperceptible.

5—The constitution of the metal composing the pipes is of extreme importance. (See above).

6—Arranging, if possible that the flow of current in the pipes shall be from the bell end of the pipe. This greatly increases the amount of metal to be acted on and confines the action to useless metal of the pipe.

7—The nature of the soil is another item of extreme importance as determining the rate at which electrolysis will take place. Thus, tests made at Liverpool, England, showed that earth which is cindery or ashy, containing generally unusual quantities of sulphur causes rapid deterioration. Soils which are in the neighborhood of badly drained thoroughfares, or other places where salty material is in excess, are dangerous, etc.

In this connection it may be of interest to note that iron structures covered with porous matter, such as coke, ashes or sawdust, etc., experimentally always gave excessive corrosion.

While it is undoubtedly possible, in all cases, by careful engineering and consideration, to reduce electrolysis to any desired value and the trouble is undoubtedly capable of many solutions, it is noteworthy that few cases demand exactly the same solution with regard to minimum expense, and it is hoped that the above notes based on practical tests and experience may be of value in some cases.

THE USE OF REACTIVE COILS WITH ROTARY CONVERTERS

By J. B. TAYLOR

The Reactive coil is part of the standard rotary converter equipment, and is installed primarily to permit of automatic compounding (by means of phase regulation) and thereby to compensate for line drop; but it has a number of incidental advantages which taken together, are of about as much importance as this primary function. The advantages obtained by the use of the reactive coil, briefly summarized, are as follows:

GENERAL ELECTRIC CO.

Reactance for Use with Rotary Converters

(1) Automatic compounding in connection with the series field of a converter, to compensate, partly or wholly, for drop in the transmission line, transformers, and in the converter itself.

(2) Allows of the adjustment of the D. C. voltage through a considerable range, with either shunt or compound wound converters.

(3) Small changes in power factor under variable load, without the necessity of continual adjustment of field rheostat.

(4) Proper division of load between converters and little influenced by variable factors, such as brush resistance, brush setting, and change of field resistance, due to warming up.

(5) Permits parallel operation of machines of different manufacture, or of different design, in which the ratio of conversion is different.

(6) Permits parallel operation of converters whose transformers have not the same ratio.

(7) Favors our standard method of A C. starting by reducing the current.

(8) Limits the current which can flow into a short-circuited armature, in case of break down or flash over, so that results of such short circuits are not so disastrous.

(9) Where converters are subject to pulsations through excessive line drop, a reactive coil reduces the effect of this pulsation.

Considering these points in their order we have:

(1) Automatic Compounding

The automatic compounding is essential to the operation of our interurban railways, where the loads are variable. In large city service, this automatic compounding is not essential; but as a rule, on these large city systems, the substations are fairly close together, the feeder drop small, and the reactive coil gives sufficient range of voltage to materially assist in the desired divison of load between substations.

(2) Adjustment of Voltage

Where converters have to feed into existing systems, frequently helping out steam plants, the reactive coil has shown itself to be of value. The Chicago City Railway Company, taking power from the Chicago Edison Company, operates three 1000 kw. conevrters a few hundred feet from an old steam plant. But for the reactive coils installed here, considerable difficulty would be experienced in obtaining the desired output from the converters.

(3) Power Factor

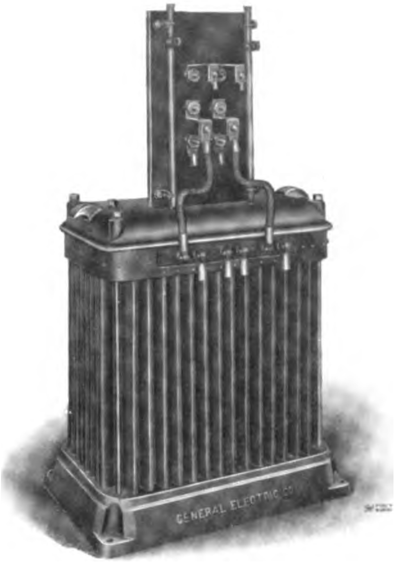
A converter with 15% reactive coil, carrying moderately fluctuating loads, will have a power factor varying between 97 and 98% lagging, to 98 or 97% leading. Without the reactive coil, the compound winding, if heavy enough to compensate for transformer and drop in converter itself, will cause much greater changes in power factor.

(4) Division of Load

Converters without reactive coil are very sensitive to resistance of brushes, setting of brushes, and field current. This tendency toward improper division of load is brought out in a paper by Mr. Sidney W. Ashe, presented at the December, 1905, meeting of the A. I. E. E., in which he says, under The Adjustment of Load Between Substations that Feed the same Circuit;—"Requires the adjustment of the power factor of all converters so as to be unity at full load; but it fails where applied broadly, owing to the practical impossibility of finding any two converters of the same capacity, although manufactured by the same company—with identical characterization and equal brush contact resistance"—and more to the same effect. This difficulty is very largely obviated by the use of the reactive coils.

(5) Different Ratio of Conversion

A number of converters have been furnished to run in parallel with both Bullock and Westinghouse machines, and where reactive coils have been included, I have never heard any complaint of difficulty in obtaining proper division of load. In one installation where two converters of different design were operated in parallel, without being equipped with reactive coils, complaint was made that the voltage from one machine was several per cent too high. The transformer taps in connection were of no assistance, as they would merely have increased the difficulty. If the standard 15% reactive coils had been installed, the difference in voltage could have been absorbed by adjusting the field rheostat. In a similar instance, in which, however, reactive coils were installed, the voltage was easily reduced to the proper point by the field rheostat.



Reactance with Starting Panel (back)

(6) Transformer Ratios

There are many cases where it has been necessary to operate transformers of different ratios in the same substation. I quote but two specific instances:

The New Hampshire Traction Company had a number of 300 kw. converter equipments, in which some of the transformers had 380 volt secondaries and others 370 volt secondaries. Due to shifting of the load, it was desirable after a time to move some converters from one substation to the other, and no difficulty was experienced in obtaining proper division of load, as the reactive coil absorbed the small difference of ratio.

On two different occasions, the Schenectady Railway Company have been obliged to use transformers at 10,000 volts, which were built originally for installation at Ballston on 30,000 volts. In one case, the transformers operated in parallel with three-phase 370 volt converter equipments, and in the other, with 430 volt six-phase converters diametrically connected. It was impossible to obtain the same ratio of transformation and in both cases the operation was perfectly satisfactory—thanks to the reactive coils.

(7) A. C. Starting

On the smaller three-phase converters, the reactive coil is in circuit on starting, and about full load current is taken from the line. Without the reactive coil, this current is very nearly doubled.

On the larger converters, which start at 1/3 voltage, the reactive coil is not in circuit while the machine is on the one third starting taps; but goes into circuit when the machine is switched to the full line voltage, and reduces the rush of current at this time.

(9) Pulsation

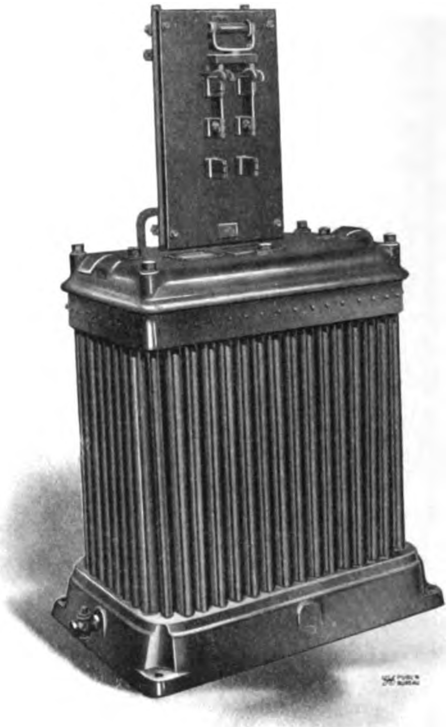
At the time when there was a single transmission line to the Albany substation of the Schenectady Railway Company, the line drop was so great that pulsation was excessive and badly crippled the service. We then connected in reactive coils and found that they materially helped matters, and the result of this, and other instances, was that the Schenectady Railway Company ordered reactive coils for all their converters, although they had been operating for sometime without them.

I know of no instance where reactive coils have been removed, or cut out of service, except in one case where the D. C. voltage was too low and some wise construction man short circuited the coil because a voltmeter across its terminals showed that there was a drop in it—needless to say he made a bad matter worse.

Electrical and Mechanical Construction of Reactances

by J. J. Frank

In the electrical design of these reactances, the loss in the iron and in the copper has been reduced to a minimum so that, in the majority of capacities, the average efficiency at all loads 97.5 per



Reactance with Starting Panel (front)

cent. By a peculiar arrangement of the core there is absolutely no stray magnetic field outside of the reactance structure, so that the potential drop is not affected by the location of the reactance relative to the steel structure of the sub-station.

In the mechanical construction of the reactances, a very successful result has been accomplished by using a tank construction similar to that of the transformer supplying power to the converter, with which the reactances operate. In the oil cooled type, the tanks are of fluted steel, the reactances being suspended from the cover, in a manner similar to that used in the latest transformer construction. In the air blast type the construction follows that of the air blast transformers very closely. Both the oil cooled and the air blast designs make a very pleasing appearance when assembled in the station with the transformer on account of the similarity in their mechanical construction.

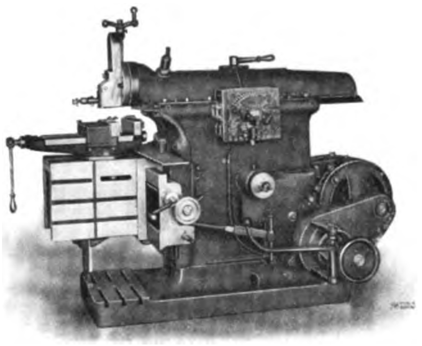
By mounting the starting panel for the converter on the cover of the reactance, as shown in the above illustration, a very convenient base or support is provided, and at the same time the total floor space required for all the necessary apparatus is reduced.

MOTOR DRIVEN SHAPER

The illustration herewith shows a very interesting and valuable application of a General Electric motor to a high speed, quick stroke, 24 in. shaper recently manufactured by Gould & Eberhardt of Newark, N. J., for the National Tube Company, Lorain, Ohio.

As will be seen, the motor, which is of the well-known CR, continuous current type, especially designed and built for use with machine tools, is mounted on the back of the main column of the shaper, thus making it integral with the tool, and at the same time keeping it well up from the floor where it will be protected from dirt or sweepings. Power is transmitted from the motor to the main shaft of the shaper through a Morse Silent Chain.

One of the particular features of interest in this electrically driven tool is found in the fact that the motor is not stopped and started each time that the tool itself is stopped or started. The motor may run continuously and by means of the long, curved lever shown at the right of the view, a clutch is thrown in or out, as occasion requires, thus giving perfect control of the cutting head without the strain or shock involved in starting and stopping the motor instantaneously.



Motor Driven 24 Inch Shaper

A very desirable feature in connection with the clutch is the mechanical brake which enables the cutting head to be brought to rest almost instantly during any portion of the stroke.

The arrangement for governing the transverse feed of the table is ingenious and effective, as is also the means for supporting the table on the extended base when heavy work is being machined.

GENERAL ELECTRIC INDUCTION MOTORS IN HAVANA, CUBA

By R. S. BALDWIN

That manufacturing interests in Cuba have not been slow to realize the advantages of electricity for power purposes, is evidenced by the increasing exports of electrical apparatus to that country. This is especially true of induction motors, two recent applications of which in Havana—one from a view point of economy alone, the other from consideration of novelty as well as economy,—may prove of interest to readers of the General Electric Review.

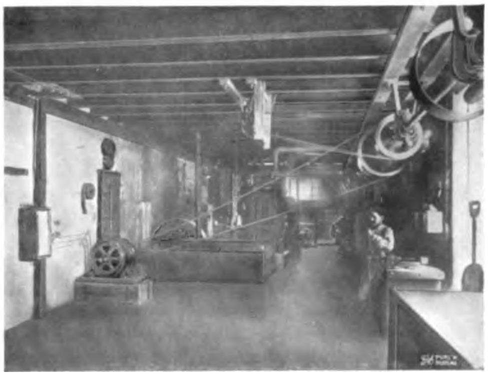


Fig. 1 Induction Motor in Cigar-box Factory

Figure 1 shows a General Electric Company's induction motor rated 1-4-15 h.p. 1200-220 volt, form L, installed in the cigar-box manufactory of Messrs. Diaz & Vega. This motor operates, through a line shaft, a large number of small circular and jig saws on the first and second floors of this establishment. The interesting part of this installation consists in the fact that a steam engine and boiler costing to install some $3500.00, when still new, were replaced by the motor above noted at a fraction of the cost of the steam plant.

The new "Centro Dependiente" Club House now building on the Prado, Havana, will be when finished, both the largest and most costly building on the Island of Cuba. Large quantities of marble tiling are being used in the construction of the floors and stair cases, for the rapid installation and finishing of which, the "Rubbing Bed and Tiling Machine" shown in Fig. 2 and 3 was devised. This machine is operated by a General Electric Company's induction motor rated 1-4-15 h.p.-1200-220 volt, form L. It is interesting to note that four men working at the electrically driven "rubbing bed" can accomplish in one day what formerly would have required a week with the same number of operators, using older methods.

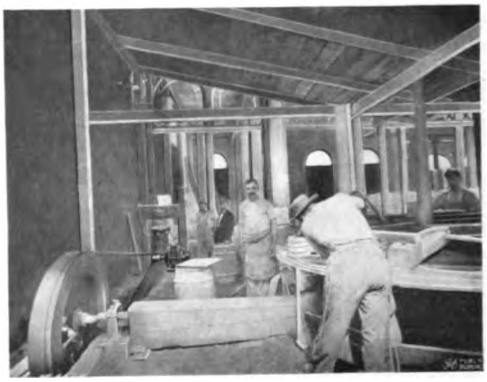


Fig. 2 Motor Operated Rubbing Bed and Tiling Machine

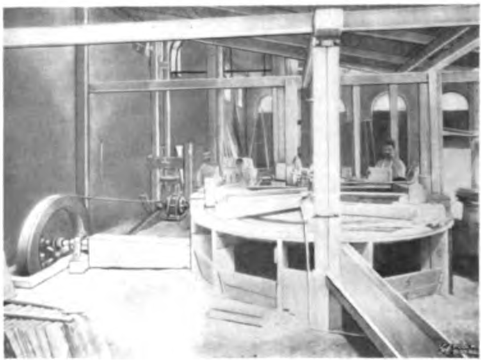
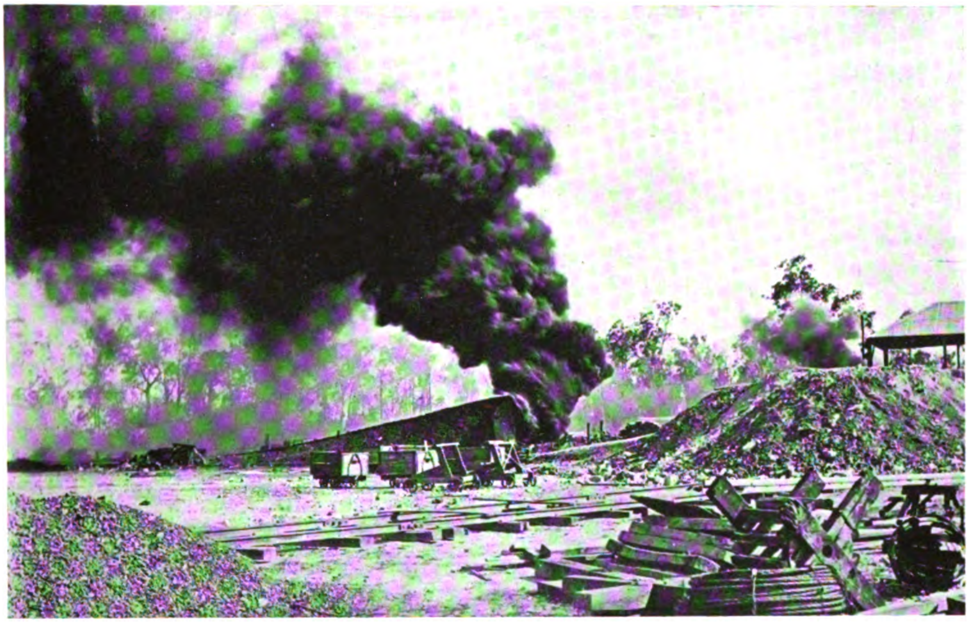


Fig. 3 Motor Operated Rubbing Bed and Tiling Machine

Both of the motors mentioned were sold through Messrs. Sussdorf Zaldo & Co., agents for the General Electric Company in the Island of Cuba.

MINE EXPLOSION

The Stanford Merthyr Colliery near Newcastle, New South Wales, is interesting because of its complete electrical equipment including seven coal cutters and various other apparatus furnished by the Australian General Electric Company of Melbourne and Sydney.



Mine Explosion

The remarkable photograph reproduced herewith was received from Mr. George R. Mair of the Australian General Electric Company. It shows an explosion which took place last spring in connection with a fire started in the loose coal in the bottom of the seam, by dropping a burning lamp wick or hot ashes from a pipe. Sealing walls in the incline tunnel, probably intended to confine the fire, backed the partly consumed fumes down into the burning section, and they exploded on coming into contact with the flames. Mr. Mair, in a letter addressed to Mr. J. R. McKee, General Manager of the Power and Mining Department, says:

"The photographer has just got his camera ready to take a photograph of the small column of smoke seen on the right which was coming from the travelling way tunnel where the first explosion took place, and just at the moment he was going to take it, the second and most severe explosion occurred in the incline tunnel shown on the left. Several people were killed, including the Chairman of the Board of Directors, and our own electrical expert just escaped by the skin of his teeth.

The explosion in this incline tunnel afforded an illustration of the fatal results attendant on disagreeing with one's Manager. Mr. A. Thomas, the General Manager of the Company, and Mr. Williams, his under-manager, were standing about 18 ft. inside the tunnel mouth discussing the best place to put in a wall to stop the draught. Mr. Thomas was standing near the right-hand rib, and, making a gesture with his right hand, said to Williams, 'I think we had better put the wall in there.' Mr. Williams, disagreeing with him, turned to the left and made a gesture in that direction, and while he was doing it the explosion took place, and the bricks from a wall farther in took off his left arm and leg. One brick cut through Mr. Thomas' thigh right to the bone and Mr. Thomas was blown from the 18 ft. inside the tunnel mouth to about 20 ft. outside of it."

NOTES

W. J. Veeder, who entered the Testing Dept. from the Machine Shops in 1901, and who had charge of Building No. 16 nights for about 3 years, left on January 26th for Kashimer, India, where he will have charge of the construction for the new development that the Kashimer Power Co. is installing.

* * *

J. F. H. Douglas, a graduate of the Massachusetts Institute of Technology, who entered the Testing Department in 1905, has left to take a position as Instructor at Cornell.

* * *

A. G. Jones, a graduate of the Alabama Polytechnic Institute, has been transferred from the Test to the Power and Mining Department for Lightning Arrester work, as has also Mr. A. B. Marvin, a graduate of Stevens Institute.

* * *

Fred N. Bushnell, who for many years has been Chief Engineer of the Railway and Lighting Companies in Providence, R. I., has resigned his position at that place, and on February 1st will accept a position with the Stone & Webster Engineering Corporation. Mr. Bushnell is to have charge immediately of the installation of 12000 Kw. of generating apparatus in the stations of the Boston Elevated Railway Company in Boston, which work has been placed entirely in the hands of the Stone & Webster Engineering Corporation. Mr. Bushnell's work for the past ten years has been along the line of construction engineering, and he recently finished the construction of a large power station for the Rhode Island Company, which is the street railway corporation of Providence.

* * *

The Stanley G. I. Electric Manufacturing Co. closed their Boston Office on January 21st, and F. P. Barnes now looks after the interests of that company from the Boston Office of the General Electric Company.

* * *

H. W. Smith, formerly Sales Agent with the Boston Office of the Stanley G. I. Electric Manufacturing Co., has recently been appointed Manager of the Boston Office of the Fort Wayne Electric Corporation. Mr. Smith has been allied with the interests of the General Electric Company for fifteen years, having started in the Railway Engineering Department at the Lynn Works, and later for a number of years was connected with the Engineering and Sales Department of the Stanley Company at Pittsfield.

* * *

C. A. Thomas, who has recently had position of Manager of the Boston Office of the Fort Wayne Electric Co., has resigned this position to take a position with the Philadelphia Office of the same company.

* * *

J. H. Waterman, formerly allied with the interests of the General Electric Co. and Thomson-Houston Electric Co., has recently accepted a position with the Milford Construction Co. at Orono, Maine. This company has just completed the construction of a large power plant on the Bodwell Water Power at that place and is to furnish power in large quantities to the large manufacturing establishments in Bangor and vicinity.

* * *

E. P. Coleman has accepted a position of Manager of the Great Northern Power Co. of Duluth, Minn. Mr. Coleman was for a number of years the Manager of the Consolidated Lighting Co. at Montpelier, Vt., and during the past two years has been devoting his entire time to consulting engineering. He is well known in this vicinity as a first class electrical and mechanical engineer and a good manager.

* * *

George deB. Green, formerly with the Railway Engineering Department at Schenectady, has been for the past year connected with the banking firm of E. H. Rollins & Co. of Boston, Denver and San Francisco, as Consulting Engineer. Mr. Green's work is in connection with the electrical properties that are either controlled or promoted by this firm, and he will be glad to take up, at any time, any matters of this character which any of his old friends may care to bring to his attention.

* * *

M. M. Corbin, formerly connected with the General Electric Co., Cincinnati, has been transferred to Philadelphia and is connected with the Heavy Traction Department there.

* * *

N. R. Edwards, formerly of the Testing Department of Schenectady, has been transferred to the Construction Department of the Cincinnati office.

* * *

N. C. Ross, formerly of the Stanley G. I. Co., is now connected with the Cincinnati Office of the General Electric Co., and is in charge of lighting work.

Oscar Carman, formerly of the Stanley G. I. Co., is now connected with the Supply Department of the Cincinnati office of the General Electric Co.

* * *

The following salesmen of the Stanley G. I. Co. have been transferred, as below:

E. L. Barr, of Chicago Office, to Power & Mining Department, Chicago G. E. Office.

L. U. Murray, of Cincinnati Office, to Cincinnati G. E. Office.

J. M. Rodger, of Kansas City Office, to Kansas City G. E. Office.

F. Johnson, of St. Louis Office, to St. Louis G. E. Office.

C. A. Mann, of Omaha Office, to Omaha G. E. Office.

C. A. Browning, of New York Office, to New York G. E. Office.

J. J. Shaughnessy, of New York Office, to New York G. E. Office.

* * *

A. H. Abell, Manager of the Switchboard & Supply Department of the Stanley G. I. Electric Mfg. Co. at Pittsfield, on January 1st went to New York Office of the General Electric Co., in connection with the commercial exploiting of heating devices.

* * *

R. F. Coggeshall, formerly of the Motor Department of the Stanley G. I. Co., has been transferred to the Power & Mining Department of the General Electric Company at Schenectady.

* * *

J. R. Lovejoy has been appointed General Manager of the Sales Department at Schenectady.

* * *

It is the purpose of the Schenectady Works management to divide the Works into sections, appointing a Superintendent who will have general supervision of the work in each of the various sections and who will be directly responsible to the General Superintendent.

Buildings 23, 24, 26 and 29 will be known as "Section A", with Mr. J. F. Madgett as Superintendent; Buildings 5, 8, 9, and 10 will constitute "Section B", with Mr. W. T. Clark as Superintendent; and Building 16 including gallery will constitute "Section C", with Mr. C. H. Buckley as Superintendent.

Mr. J. H. Shugg, formerly general foreman of the Armature Dept., is appointed Superintendent of "Section D", which comprises Building 14 (with the exception of core work), Buildings 15 and 22, armature and field work in Buildings 20 and 86, tool work in Building 25, insulating work in Building 91, and field coil work in Building 11.

Mr. E. F. Collins is appointed "Superintendent of Testing Departments" in charge of Testing Department quarters in various buildings.

* * *

An Information Bureau is being organized at Schenectady, with Mr. Waters in charge, to keep track, through the local offices and other sources of information, of electrical interests and activities everywhere. It is intended to make this Bureau a source of help to the sales organization, by keeping them in touch with what is being done in every branch of the electrical field.

To make this Bureau effective, it is essential that the local offices should cooperate with the Bureau by furnishing full information of sales, losses of business, satisfaction and dissatisfaction of customers, etc.

* * *

A Switchboard Department is to be organized, to meet the demands due to the large increase in Switchboard business. Mr. J. W. Upp has been appointed manager of this department, and will have charge of the preparation of proposals, costs, deliveries, engineering, drafting, requisitions, production and manufacture of switchboards and switchboard appliances. Department engineers will act in a consulting capacity, as heretofore. The Commercial Department will continue to have charge of the sales.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Schenectady Branch

The meetings of the Schenectady Branch, American Institute of Electrical Engineers, held during the month of January, were well attended by men from all departments.

During the last two months considerable interest has been manifested in the association outside of the strictly engineering departments, and a large number of new members have also been registered from the different shops. The influence of the Branch in attracting men to the Institute is rather interestingly shown by the list of new members published in the December Proceedings, A. I. E. E. Out of fifty-four new members elected at the November meeting, thirteen were from Schenectady and six from General Electric branches or allied companies, 35 per cent in all, of which probably one-half can be directly traced to the efforts of the Branch.

The speakers during January were local men, and the papers in general of great educational value.

On January 5th, Prof. E. E. F. Creighton of Union University and General Electric Company, read an abstract and discussed a paper on "Lightning Protection" recently presented before the Institute in New York. The author of the original paper was R. P. Jackson of the Westinghouse Electric & Manufacturing Company, and it described many different lightning arresters now in use, with interesting tests made to determine their relative efficiency.

Prof. Creighton is one of the authorities in this country on the protection of electrical installations from the effects of atmospheric disturbances, and his audience listened with interest as he explained the technical details of the paper and described the different practices of the two big electrical companies.

Chairman D. B. Rushmore, who presided, pointed out the vast importance of this subject. Several immense power developments are now being held in abeyance awaiting absolute assurance that the high voltage transmission lines necessary for their successful operation can be satisfactorily protected from lightning, and the electrification of long distance railroad lines cannot be effected until the problem is solved.

In no other branch of electrical engineering is the investigator so closely in touch with the fundamental character and inherent nature of electricity, and in no other branch does expert opinion appear to differ so widely. From either the commercial or scientific side, therefore, the invitation to the young engineer to enter the field is most enticing.

A number of men familiar with the subject participated in the discussion, among them being Messrs. Du Bois, Merriam, Goodwin, Loizeaux, Worcester and Eichel, bringing out different phases of the practical design and operation of various types of apparatus.

On January 12th, a very instructive paper was read by Ernst J. Berg, entitled "Some Features of Parallel Operation of Alternating Current Generators". Mr. Berg confined himself largely to a discussion of the formulae involved as being more useful for the substituting of actual numerical values and illustrated examples, but also gave in his explanations a few diagrams which illustrated the principles. A number of the members who participated in the discussion following the reading of the paper gave accounts of their experience in this line of work and highly complimented Mr. Berg's investigation of the subject. Among those who spoke were A. A. Tirrill, E. B. Merriam and C. T. Wilkinson. The first part of this paper was published in the January number of the REVIEW.

At the meeting of January 19th, a topical discussion on Industrial Betterment was held. It was opened by William Dalton of the American Locomotive Company, who spoke of the existing industrial conditions, and the efforts being made by employers to better them.

Messrs. Cravens, Maxwell, MacMillan, Wright and Hewett, all of the General Electric Company, discussed the subject from various points of view, Mr. Maxwell asking for what he considered were desirable betterments of the condition of the testers.

Two papers on the application of electricity to mechanical operations were presented on January 24th. Both were profusely illustrated by lantern slides.

Maxwell Day, of the General Electric Company, gave a talk on "Centrifugal Fans". The many uses to which blowers and fans have been placed commercially for forced draught, ventilation, etc., has resulted in reducing the design and manufacture of this class of apparatus to a special branch of mechanical engineering. Mr. Day, showed, by means of numerous views, the different classes of fans, the requirements which determine the selection of certain types, and the principal features of their construction. Methods of testing were described and a number of charts giving comparative efficiencies of different types at various loads were thrown on the screen. An article by Mr. Day upon this subject was published in the January issue of the REVIEW.

H. B. Emerson, of the General Electric Company, read a paper on "Electric Drive for Metal and Wood Working Machines". The subject covered the applications of both alternating and direct current electric motors in the operation of various types of machines, large and small. Constant and variable speed requirements were discussed, with special reference to the selection of the most servicable apparatus for various conditions.

SALES NOTES

Orders have been received for the following:

Seattle Electric Co., Seattle, Wash. MP 6-500-720-275 volt generator direct connected to an AQB 10-530-720-2300 volt synchronous motor, with direct connected exciter. MP-6-500-720-275 volt generator, direct connected to an AQB 10-530-720-2300 volt synchronous motor, with direct connected exciter. Two WC 60-13800/2300 volt transformers.

The above motor generator sets will be of the three bearing type and will be used for lighting. They are to be used on three-wire lighting circuit. The direct connected exciter to be furnished for each synchronous motor is mounted on shaft extension at the AC end of each set. Each set is to be furnished with a two-phase compensator for starting from the AC side. Also, a suitable rheostat for starting from the DC end. By this arrangement these sets can be phased in from either the direct or alternating side.

Stone & Webster. Seattle Electric Co., Seattle, Wash. One MP 6-500-720-600 volt generator with one ATB 10-530-720-13200 volt synchronous motor.

One MP 10-1000-514-600 volt generator with ATB 14-1000-514-13200 volt synchronous motor. These sets are to be used in connection with railway work. The power will be transmitted at 13200 volts AC and fed into the line at 600 volts DC.

38 4-motor GE-80 A equipments with K-6 controllers.

* * *

The Arlington Mills of Lawrence, Mass., have placed order with us for a second 2000 kw., 40 cycle turbo alternator. The first unit was installed and started last fall, and has only been in operation a short time, but has been so satisfactory that they feel warranted in immediately placing an order for a second machine. The generator of this unit is wound for 600 volts and is to be used principally for the distribution of power through their large mills.

A peculiar feature in connection with each turbine is that it is so arranged that steam can be taken from the second stage under 5 lbs. pressure to be used in the Dye House, and the turbines will generally be operated under these conditions. Both units are of the condenser base type.

* * *

William Sellers & Co. have placed orders with the General Electric Company for 36 C.L.C. 6-27 1/2 h.p. 430/1300-230 volt commutating pole direct current motors, for use in the Midvale Steel Co. This is the largest order for DC commutating pole motors that has been shipped to one manufacturer. This type of motor is especially adapted for machine tool drive, pumps and hoisting, and is equally applicable to other machinery where both varying loads, heavy starting torque and suitable speed variation is required, as when operating on weak field, the sparking is practically eliminated.

The General Electric Co. carries a full line of these machines, at 115, 230 and 500 volts, varying from 3 3/4 h.p. constant duty to 130 h.p. intermittent duty.

A complete description of these motors is given in the recent Bulletin, No. 4462.

* * *

An order has been received from the Bath Iron Works of Bath, Me., for two 35 kw., 125 volt direct current turbo-generator sets, together with a complete switchboard and one 18 in. projector for pilot house control. The following quotation is in reply to inquiry as to where these turbines are to be used:

"The two 35 kw. turbines and other apparatus called for on our order are to be used for lighting the triple screw turbine steamer Camden, building by this company for the Eastern Steamship Co., to run on the Boston-Bangor route. This steamer is 320 ft. long, 40 ft. beam, 14 ft. depth of hold; designed to work at a 10 ft. draft. She is equipped with 4000 h.p. turbine machinery designed to run at 17 knots speed. She has a large passenger and freight accommodation, and is intended to be a step in advance with a view of taking care of the Eastern Steamship Co.'s growing business on the Bangor run."

It seems quite fitting that a steamer which is to be propelled by turbine engines should be lighted also by engines of this type.

* * *

St. Joseph Railway Light, Heat & Power Company, of St. Joseph, Mo., have placed orders for 10 CP-21 emergency straight air brakes for motor cars, and 50 emergency air brakes for trail cars. This order was taken after competitive test with two of the leading brake companies, which test was carried on before the Engineers and Operating Managers of the E. W. Clarke Co., and was exceedingly rigid. The apparatus being taken apart and examined in detail.

This Railroad is one of the Clarke Syndicate's, and the test was made to determine the question of brake equipment for a number of other lines.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

* Illustrated

Meeting of the Mechanical Engineers

[Electrical World, Dec. 15, '06, p. 1143]

Brief note, relative to excursions made by the members of the society to the 20,000 kw. plant of the New York Central R. R. (which is equipped with General Electric Machinery exclusively); also, to Sandy Hook, to inspect the coast defence, including the operation of heavy ordnance, such as 12 and 16 inch guns.

A feature of special interest was the handling of a 12 inch disappearing gun, operated by electric power, the power being supplied by a General Electric motor generator set, located in the casemate near the gun, which set receives its energy from the main generating station on the grounds.

Power Plant of the Southside Elevated Railway in Chicago

[Western Electrician, December 1st, 1906, p. 433]

"The main power-house of the Southside Elevated Railway was built at State and 40th Streets, adjoining the elevated tracks, and represents, with its combined maximum capacity of 32,000 h. p., the largest reciprocating-engine-equipped power-house in Chicago. The electrical machinery, consisting of nine General Electric Company direct current generators, is rated at 11,700 kw. total capacity, and comprises:

four 800 kw. machines,
three 1500 kw., and
two 2000 kw. units.

Both engines and generators are capable of a 50% overload for considerable periods.

The machines of special interest are the big MP 22-2000 kw.-75 r. p. m. 650 volt. generators, the complete armatures of which, including commutator, weighs 87,000 lbs. each, while the weight of an entire generator amounts to 188,000 lbs. These machines are guaranteed to run for 24 hours at full load capacity without increasing the temperature in any part over 30 deg. C. A 50% overload can be carried for two hours, with a temperature rise not exceeding 55 deg. C.

The switchboard of this interesting power-station was installed by the Chicago Edison Company, and is equipped almost exclusively with General Electric Company apparatus, and includes laminated brush toggle lever switches of 6000 and 9000 ampere capacity, also high capacity carbon-break circuit-breakers, for the feeder panels.

Standard of Construction of the Fort Wayne & Wabash Valley Traction Company

[Street Railway Journal, Dec. 1, '06, p. 1034*]

An interesting description of the Bluffton Line, which extends due south of Ft. Wayne for a distance of 25 miles. It is owned by the Ft. Wayne, Bluffton & Marion Railway, and controlled by the Ft. Wayne & Wabash Valley Traction Company.

Power is supplied by a 16,000 volt, 25 cycle, three-phase transmission line, from the power-house in Fort Wayne to a sub-station equipped with type H transformers and a 300 kw. General Electric rotary converter, also necessary switchboard and high tension oil switches of General Electric make. Space is provided for one additional 300 kw. unit.

The Great Northern, Picadilly & Brompton Railway

[Electrician, (London) Dec. 7th, '06, p. 281]

The above named railway is the second of the tube systems, associated with the Underground Electric Railways Company, of London, which have at present, a total length of, approximately, 9 miles. The greater part of the railway is in twin iron tube tunnels, and power is supplied by the Chelsea Power Station, and a number of A. C.-D. C. rotary sub-stations, to the rolling stock, which consists of 75 motor cars and 144 trailers.

The 49 ft. 1 1/2 in. motor cars seat 46 passengers, and the trailers, 52 pessengers each, so that the standard 6-car train, which is made up of 2 motor cars and four trailers, will accommodate 300 passengers with seats.

The electrical equipment of the rolling stock, consisting of two GE 69 (200 h. p.) motors per car, controlled by standard Sprague-Thomson-Houston multiple unit system, was supplied by the British Thomson-Houston Company, and is about identical with the equipment which has been extensively used on the District, and on the Baker Street & Waterloo Railways and in some of the newer trains of the Metropolitan Railway.

The Hydro-Electric Plant of the Belton Power Company

["Electrical World", Dec. 15th, '06, p. 1147*]

The hydro-electric power development of the Belton Power Co. located on the Saluda River, at a point about seven miles east of the town of Belton, South Carolina, comprises a power-house with

Three 1000 kw., 200 R. P. M., 2300 volt, 60 cycle, three phase alternators,

One 100 kw., 600 R. P. M., 2300 volt, 60 cycle, three phase generator, with direct-connected 5.5 kw. exciter.

One 55 kw. 625 R. P. M. exciter.

All direct-driven by horizontal shaft, water turbines.

Also, one 58 kw., 925 R. P. M., exciter, to be belt driven by either of two main alternator units.

Power is stepped up in a bank of six 500 kw., 2300-22500 volt transformers, and transmitted about 13.5 miles over an aluminum cable transmission line equipped with grounded guard conductor, to sub-stations at Belton and Williamston. The sub-stations contain, in addition to the 22500/600 volt step-down transformers, small units to step down to 2300 volts, for the lighting and power of the towns, and for the operation of 6.6 ampere constant current transformers for arc lamp and street lighting.

The main current is used for electric motor group drive of the Belton and Williamston mills, which are equipped with induction motors ranging in size from 50 to 300 h. p. each.

The small power station unit carries the night load for the power and light supply, thus avoiding the uneconomical operation of one of the large units during night load.

The entire electrical equipment was furnished by the General Electric Company.

INDEX

Page

Alternators, Hunting of, By Ernst J. Berg.... 61

A. I. E. E. Schenectady Branch Notes........ 84

Boats:
- Eastern Steamship Co. (see "Mills" Bath Iron Works) 86

Central Station:
- Commercial Importance of Heating Devices to the, by Errett L. Callahan 56

Contracters:
- Sellers & Co., William.................... 86
- Stone & Webster, (see Seattle Electric Co.) 86

Cranes and Hoists:
- Truxal Painter Hoists, Motor Driven, by Fred M. Kimball 72

Electrolysis:
- Electrolysis of Buried Iron Structures, Some Chemical Aspects of, By C. T. Wilkinson 73

Generating Systems:
- Belton Power Co., Hydro-Electric Plant of. 87
- Seattle Electric Co., Seattle, Wash........ 86
- Southside Elevated Railway, Chicago, Power Plant of 87
- (See also "Traction.")

Heating Devices:
- Commercial Importance of, to the Central Station, by Errett L. Callahan 56

Mechanical Engineers, Society of............. 87

Mills:
- Arlington Mills, Lawrence, Mass.......... 86
- Bath Iron Works, Bath, Me.............. 86
- Midvale Steel Co. (see William Sellers & Co.) 86
- (See also "Motor Drive.")

Mine Explosion 81

Motor Drive:
- Induction Motors, General Electric, in Havana, Cuba, by R. S. Baldwin 80
- Motor Driven Shaper..................... 79
- (See also, "Cranes and Hoists," "Mills" and "Ordnance.")

Page

Notes 82

N. Y. C. & H. R. R. Electrical Equipment of, by A. Smith 45

Ordnance, Motor Operated (see "Meeting Mechanical Engineers" 87

Paralleling of Alternators, (see "Alternators")

Reactances:
- Reactive Coils, Use of with Rotary Converters, by J. B. Taylor and J. J. Frank.. 76

Shaper, Motor Driven, 24 inch................ 79

Traction:
- Fort Wayne & Wabash Valley Traction Co., Standard Construction of 87
- Great Northern, Picadilly & Brompton Railway, London, England 87
- N. Y. C. & H. R. R., Electrical Equipment of, by A. Smith 45
- St. Joseph Railway, Light, Heat and Power Co., St. Joseph, Mo. 86
- (See also "Generating Systems")

Transformers:
- Tank Construction for, by J. J. Frank 54

Transmission:
- Line Constants and Abnormal Voltages and Currents in High Potential Transmissions, by Ernst J. Berg 64
- (See also "Generating Systems" and "Traction")

Tunnels:
- (See "Traction" Great Northern, Picadilly & Brompton Railway.)

Water Power Plants:
- (See "Generating Systems" Belton Power Co., Hydro-Electric Plant of)

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GENERAL ELECTRIC COMPANY REVIEW

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THE TRAINING OF ELECTRICAL ENGINEERS

By F. B. CROCKER

Professor of Electrical Engineering at Columbia University, New York City

This matter, not only from the educational point of view, but also from the standpoint of the manufacturer and other employers of electrical engineers, has occupied much of my time and thoughts for the past seventeen years. It is now generally recognized that a course of instruction in some technical school is an almost necessary preparation for entering the electrical engineering profession. Formally this was not so, some men having achieved eminence and many having been successful without this educational training, but the percentage of these cases becomes less and less as time goes on. It is still possible, however, for one to reach high positions in the electrical field, especially on the business side, by rising from the ranks, so to speak, just as one may become a major general of the United States Army without graduating from West Point. In fact, some of our most prominent army officers of the present day are not West Pointers. It is even desirable, I think, that this opportunity should always remain, not only in the army but in the engineering professions.

It is natural, however, for the writer to consider the question from the view point of the technical school and perhaps to be prejudiced in favor of it. The present discussion will therefore be confined to that form of training.

The advantages that such a training give, may be briefly enumerated as follows:

First: The thorough knowledge gained of fundamental subjects, such as mathematics, physics and chemistry, upon which all engineering is based.

Second: The training is systematic and teaches the student how to think and investigate logically and effectively.

Third: A special and fairly complete grasp is secured of one branch of engineering as well as of the allied subjects. The total time occupied is only four years, while it is doubtful if the same knowledge could be picked up in ten years outside of an educational institution.

Fourth: The "practical" engineer knows certain branches intimately, but there are other equally important ones about which his mind is almost a blank. This is not usually the case with the educated engineer. The practical man simply learns from experience, and, from lack of opportunity, usually fails to fill in the gaps of his knowledge.

On the other hand, the completeness and corollation of the different branches of scientific instruction makes a technical education particularly strong and useful. The principles of science remain unchanged, so that any new invention is intelligible to a scientifically trained mind, but has to be learned as a new subject by a purely practical man. Science has now become so exact that it can be applied directly to practice without great modification, especially in electrical engineering. The apparent contrast or opposition so often pointed out between theory and practice is becoming less and less as both science and practice advance. Technical instruction should be directly based upon correct theory, but should lead up to practical results. Commercial apparatus and methods often give the most excellent examples of scientific principles.

The article by Mr. B. A. Behrend on "Engineering Education", which appeared in the Electrical World of January 5th, discusses this question very fully, and in a manner with which I fully agree. Mr. Behrend makes the following statement which I consider of the highest importance and perhaps the most so of any one of the points involved. He says "The more theory in college the better. The students cannot receive good practical instruction at college, hence let them get as much theoretical training as possible. Mechanical laboratories are much better than foot-ball, but they do not at all take the place of a year's training in a shop."

In an article which the writer published in the Columbia Engineer in May, 1897, it is also pointed out that "it is a fact that technical training does not give a business knowledge and I do not think it should attempt to give anything like a complete business education; it would be out of place and probably futile to do so. There is another thing that a technical education fails to give, that is, knowledge of human nature and the ability to deal successfully with superiors, equals and subordinates." These three points sum up, I think, the principal results that technical training cannot be expected to accomplish. I am in thorough accord with Mr. Behrend in insisting that after all, the inculcation of fundamental principles and correct theory is the real function of technical education, and much more appropriate than an effort to give an imitation of factory and central station methods. The writer does not mean, and I am quite sure that Mr. Behrend did not mean, that practical matters are to be ignored in colleges, but that the theory should be *real theory* as he calls it and should lead up to the practical applications.

Another point which I urge strongly is the importance of not specializing too greatly or too early in technical instruction. It is practically inevitable that an electrical engineer will devote nearly all of his time to the study and work of his profession. His time is occupied with reading electrical journals, letters, contracts, etc., in discussing electrical topics and in handling electrical apparatus. He has little or no time (and this is borne out by the experience of at least nine men out of ten) to study or even to consider other branches of science or technology. For example, it is not likely and hardly possible for him to sit down and study chemistry, metallurgy, or other non-electrical subjects. It is most desirable, therefore, that a certain amount of such knowledge, at least the fundamentals, should be acquired by him while he is young and has the benefit of systematic instruction. If he does not secure the knowledge then, he is never likely to, and will almost necessarily, either unconsciously or deliberately, dodge any chemical or metallurgical question that may arise in his experience. The undergraduate student is particularly short-sighted in his views on this subject. He regards any time spent on topics that are not strictly electrical, and directly bread winning at that, as being wasteful of his valuable time. As a matter of fact, it is not too much to say that the non-electrical instruction which he receives is more important than the special electrical work. This is because he will never have another opportunity to acquire the other subjects, while his whole life will be spent in gaining electrical information.

As a corollary to this conclusion, I would say that it is not desirable for the non-electrical subjects, such as mathematics, chemistry, mechanical engineering, etc., to be taught by electrical engineers or electrical specialists. The latter would naturally look at the subject from their own standpoint and pick out those particular parts which they consider important to the electrical engineer, and would therefore narrow his mind and the breadth of his information at the very start. Specialization is necessary and it is hard to succeed without it, but it should not begin too early, certainly not in the first year or two of a college course.

If not too much pressed for time and money, it is a good thing for a young graduate of a technical school to pursue a year's post-graduate course, which extends and crystallizes his knowledge. In the long run such a man will probably rise higher. On the other hand, some make the mistake of clinging too long to the skirts of their Alma Mater, so that they become unfitted to face the world. Business conditions are very different from the academic. It is advantageous, in fact almost essential, for the young graduate to serve an apprenticeship of a year or more, preferably in a large manufacturing establishment. This is true even though he intends to become a power plant engineer, contractor or consulting engineer, because he will always have to deal with apparatus which originates in a factory, and it is very important for him to know how it is made. Furthermore, the inspiration and object lesson of a large manufactory are most impressive. There, in a few months, he will get plenty of the "practical" and more of it than he can acquire in as many years in any technical school or college. At every turn he will see and be able to understand applications and embodiments of the principles which he has been taught, without which he would labor under a great disadvantage.

SURGES AND OSCILLATIONS

By CHARLES P. STEINMETZ

Electric power can be considered as the product of two factors; a quantity factor, called current, and an intensity factor, called pressure, voltage, e.m.f., potential difference, etc. The same resolution into two factors is found in most forms of power. Thus a water power is the product of the volume or flow of water, and its pressure or head, etc.

If electric power flows through a circuit, power is continuously consumed in the circuit or conductor. This loss of power is proportional to the square of the current, and to a constant of the circuit, which is called its resistance r.

In the space outside of the conductor, however, certain phenomena also take place during the flow of power.

A condition of magnetic stress, or magnetic field, exists in a direction concentric to the conductor, and a condition of electrostatic stress, radial to the conductor. That is, the lines of magnetic force surround the conductor as approximately concentric circles, and the lines of electrostatic force issue from the conductor radially.

It requires no power to maintain the magnetic or electrostatic field, but it requires energy to produce it, and when stopping the flow of power, as opening the circuit, this energy is returned to the source of power, or destroyed.

It follows from this that an electric current cannot be instantly started, stopped or changed, but whenever any change is produced in the flow of power, a certain time must elapse before the flow of power has assumed stationary condition. This transient period, during which the energy of the magnetic and electric field is given by the electric power supply, or returned, may vary from an infinitely small fraction of a second to several seconds, depending upon the amount of power stored as magnetic or electrostatic field.

The energy of the electro-magnetic field of the circuit is proportional to the square of the current, and to a constant of the circuit, which is called its inductance L. The energy of the electrostatic field is proportional to the square of the voltage, and to a constant of the circuit, which is called its capacity C.

Any electric circuit therefore has a resistance r, which represents the consumption of power in the conductor: i^2r, an inductance L, which represents the storage of energy as magnetism: $\frac{i^2 L}{2}$ and a capacity C, which represents the storage of energy as electric charge: $\frac{e^2 C}{2}$

In the earliest forms of electric machines, the friction machines, etc., high voltages were produced, but extremely small current, so the energy of the electro-magnetic field was negligible, and that of the electrostatic field considerable, that is, we spoke of "charging" and "discharging" conductors.

In most electric circuits of the present day, as the electric lighting circuits, electric railway circuits, and even 2000 volt primary distribution circuits, the energy stored by the capacity is negligible compared with the energy of the magnetic field of the circuit, so only the latter needs to be considered. That is, in starting the current, first the stored energy of the magnetic field has to be supplied, and thus the current gradually rises to its permanent value; or in stopping the current, it cannot instantly stop, but its stored magnetic energy must first be given off. Thus an attempt to instantly open an inductive circuit results in the destruction of the stored magnetic energy at a very rapid rate, or a very high e.m.f. is induced.

Electric circuits, in which the magnetic as well as the electrostatic energy is of considerable value, have become industrially important only with the development of long distance transmission in the high potential transmission line. In such a circuit, the magnetic energy is considerable, due to the large current, and the electrostatic energy is considerable, due to the high voltage.

In such a circuit, in which energy can be stored in two forms, as magnetic and as electrostatic, a change of the circuit, which requires a decrease of one of the energies, does not necessitate its destruction, but the energy can be converted into the other form. Thus when opening the circuit of a transmission line, the magnetic energy must disappear with the current, and is converted to electrostatic energy, that is, the voltage rises until the capacity C has absorbed the magnetic energy, $\frac{i^2 L}{2}$. This increased voltage, however, produces a return current, and so reconverts the electrostatic energy into magnetic energy. The current, having no exit from the open line, must again stop, and once more converts its magnetic energy into electrostatic. Thus the stored energy surges between electromagnetic energy, $\frac{i^2 L}{2}$, and electrostatic energy $\frac{e^2 C}{2}$. During every conversion of energy from electro-magnetic to electrostatic and back, some energy is consumed by the current in the resistance, and the oscillations therefore gradually decrease and stop, the more rapidly, the greater is the resistance of the current.

So when short circuiting a line, electrostatic energy disappears by conversion into magnetic energy, as a current rush, then appears again by re-conversion, etc.

In nature wherever energy can be stored in two forms, any change of condition which requires a change of the stored energy produces in this way an oscillation or transformation of energy from the one form to the other and back, until gradually the energy is dissipated in the resistance. Thus in a pendulum, a water wave, etc., mechanical energy is converted from velocity energy to energy of elevation and back continuously.

The phenomena of surges and oscillations of transmission lines are thus analagous to the oscillations of a pendulum, of the particles of water in a wave, etc.

From this then the voltage which may be produced by a surge in a transmission line can be easily calculated:

If L = inductance, C = capacity of the line, and the current i is suddenly interrupted,

its magnetic energy $\frac{i^2 L}{2}$ is converted into the electrostatic energy, $\frac{e^2 C}{2}$, that is:

$$\frac{e^2 C}{2} = \frac{i^2 L}{2}, \qquad (1)$$

or:

$$e = i\sqrt{\frac{L}{C}} \qquad (2)$$

The larger the current i, the higher is the induced voltage.

The largest current which may flow in a transmission line is the short circuit current i', and the highest possible induced voltage of a surge of the line is therefore

$$e' = i'\sqrt{\frac{L}{C}} \qquad (3)$$

Since for high potential long distance transmission, alternating currents are used, these phenomena are of importance only in alternating current circuits. Obviously, the same oscillations would occur in high potential direct current transmission lines.

If:

e_0 = rated or full load voltage,

i_0 = full load current of the transmission line,

and if:

p = impedence voltage of the line (including transformers, generators, etc.)

q = charging current of the line,

as fractions respectively of full load voltage e_0, and full load current i_0,

we have, approximately:

$$i_0 x = p\ e_0 \qquad (4)$$

where:

$x = 2\ N\ L$ = reactance of the circuit, (5)

N = impressed frequency.

And also:

$$e_0 k = q\ i_0$$

where:

$k = 2\pi NC$ = capacity admittance of the circuit.

We have therefore, dividing (4) by (6):

$$\frac{pe_0}{q i_0} = \frac{i_0 x}{e_0 k}$$

$$\text{or}\quad \frac{p}{q}\left(\frac{e_0}{i_0}\right)^2 = \frac{x}{q} = \frac{L}{C}$$

$$\text{or}\quad \sqrt{\frac{L}{C}} = \frac{e_0}{i_0}\sqrt{\frac{p}{q}}$$

The short circuit current i' is given by:

$$\frac{i'}{i_0} = \frac{e_0}{pe_0} = \frac{1}{p} \qquad (10)$$

that is, while full load current i_0 consumes the voltage $p\ e_0$, the short circuit current i' consumes the total voltage e_0.

Therefore:

$$i' = \frac{i_0}{p} \qquad (11)$$

and the voltage e' of the short circuit surge, by substituting first (11), and then (9) in (3), is

$$e' = i'\sqrt{\frac{L}{C}} = \frac{i_0}{p}\sqrt{\frac{L}{C}} = \frac{e_0}{p}\sqrt{\frac{p}{q}} = \frac{e_0}{\sqrt{pq}} \qquad (12)$$

that is:

$$\frac{e'}{e_0} = \frac{1}{\sqrt{pq}} \qquad (13)$$

or:

The short circuit surge of a transmission line raises the voltage to $\frac{1}{pq}$ times the normal, where p is the impedence voltage, and q the charging current of the line, as fractions, respectively, of full load voltage e_0 and full load current i_0.

If for instance:

$p = 30\% = 0.3$, that is, the impedence voltage equals 30% of the voltage e_0 impressed upon the line, and $q = 15\% = 0.15$, that is, the charging current of the line equals 15% of full load current i_0.

$$\frac{e'}{e_0} = \frac{1}{\sqrt{0.3 \times 0.15}} = 4.72$$

That is, in this particular circuit a short circuit surge raises the voltage to 4.72 times normal.

At normal frequency N, and normal voltage e_0, the line absorbs the charging current $q\, i_0$.

At a frequency N′, and voltage e′, it would therefore absorb a charging current:

$$\frac{N'}{N} \times \frac{e'}{e_0} \times q\, i_0 \qquad (14)$$

If N′ is the frequency of the short circuit surge, the current (14) is the short circuit current i′, that is:

$$\frac{N'}{N} \times \frac{e'}{e_0}\, q\, i_0 = i'$$

or

$$\frac{N'}{N} = \frac{i'}{i_0} \times \frac{e_0}{e'} \times \frac{1}{q} \qquad (15)$$

Substituting herein (10) and (13), gives:

$$\frac{N'}{N} = \frac{1}{p} \times \sqrt{pq} \times \frac{1}{q} = \frac{1}{\sqrt{pq}} \qquad (16)$$

That is, the frequency N′ of the short circuit surge is $\frac{1}{\sqrt{p\, q}}$ times the normal frequency, or, in above instance, 4.72 times the normal frequency, which, on a 60 cycle system: N = 60 gives N′ = 283 cycles as the frequency of the short circuit oscillation, or a rather low frequency.

If instead of the whole line, only a part of it be set in oscillation, the inductance L is correspondingly lower, and the capacity C is lower in the same proportion, so that the voltage of the oscillation (2)

$$e = i\sqrt{\frac{L}{C}}$$

is the same as when the whole line surges. The energy of oscillations, however, are:

$$\frac{i^2 L}{2} \text{ and } \frac{e^2 C}{2}$$

and therefore the destructiveness of the surge is lower. At the same time, the frequency of oscillation is higher, since a shorter time is required to charge the shorter section of the line up to the same voltage e. So if the oscillation is limited to a short part of the line, as when caused by a spark discharge from the line, etc., the frequency of the oscillation is very high, and while the voltage may be just as high with a surge of the whole line, the energy which oscillates is small, so that the oscillation may be harmless, except for the ever present danger that such a harmless high frequency low power oscillation may start an oscillation of the whole system, of low frequency—a few hundred cycles—and very great energy, and thus of high destructiveness.

In general, it is customary to speak of oscillations of the whole system, or of a large part of it, as surges, and of oscillations of a small part of the line, as high frequency oscillations.

It follows herefrom, that surges and oscillations in high potential transmission lines are nothing mysterious, but are the same phenomenon which occurs wherever energy is stored in two different forms; that their power can be calculated from line inductance and capacity, or from line impedence voltage and charging current, and is the stored energy of the system, or part of the system which oscillates. Therefrom the voltage and the frequency of the oscillation can be calculated. Low frequencies and destructive amounts of energy, appear in surges of the whole system, and the power decreases and the frequency of oscillation increases, the shorter the section of the system affected by the disturbance which causes the oscillations.

STARTING COMPENSATORS

By E. F. GEHRKENS

Transformer Engineering Department

Some form of starting device, the function of which is to limit the current taken from the line by the motor in starting, is used for alternating as well as for direct current motors, and for both the induction and synchronous types; but, as the starting compensator is used principally in connection with the squirrel cage type of induction motor, the present discussion will refer only to the various methods now in use for starting this kind of machine. An induction motor designed to meet the best condition of normal operation, should have as low an impedence as practicable, but a motor of this description necessarily takes a very large current in starting, this current being inversely proportional to the impedence; the starting torque is consequently high, and, being in the majority of cases much higher than necessary, some sort of a device is usually provided to limit the current to a reasonable amount which is still sufficient to produce the torque necessary for starting. The starting devices at present used for this purpose may be classified as follows, viz.:

Starting Compensators,
Starting Reactances and
Starting Resistances.

An induction motor requires a certain amount of current to start, and, to obtain this current, since the applied voltage is the only factor susceptible of adjustment, it is immaterial, as far as the starting of the motor is concerned, whether this result is secured by means of a resistance, a reactance, or a compensator; or whether the voltage necessary to produce this current is applied at once or gradually.

The compensator, however, is used almost exclusively, the reason for this being that for a given condition of starting, the current taken from the line with a compensator is always less than with either a resistance, or a reactance. These latter devices have the disadvantage of taking the same amount of current from the line at 100 per cent voltage as they deliver to the motor at a lower voltage, the reduction in the voltage being dependent upon the resistance of the device, whether ohmic or reactive. They therefore simply serve to reduce the current taken from the line by limiting it to the amount actually required by the motor to start.

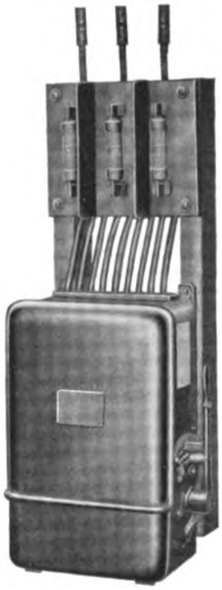
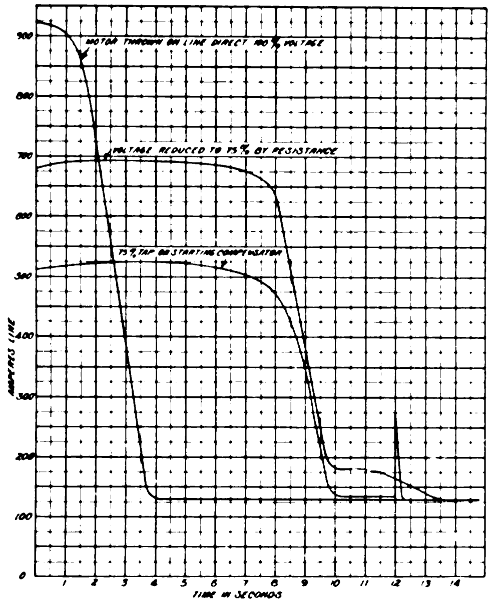


Fig. 1. Single Tap Compensator, Type CR, Form F

A starting compensator, however, consists of an inductive winding with taps, together with a switch for connecting the motor thereto. By the operation of this device a reduced potential is impressed upon the motor to bring it up to speed. With the switch in the starting position, the arrangement is equivalent in effect to a step down transformer, and the product of potential times current on the line circuit is approximately equal to potential times current on the motor circuit. To illustrate: Assume that 50 per cent of the normal voltage is sufficient to start the motor. With this potential, the motor takes one-half of the current that it would take if thrown on the line direct, i. e., one-fourth of the volt amperes. Assuming the current taken from the line by the motor if thrown on the line direct as 100, the use of a starting resistance or a reactance would reduce it by one-half or to 50, and the use of a compensator would reduce it by three-fourths, or to 25.



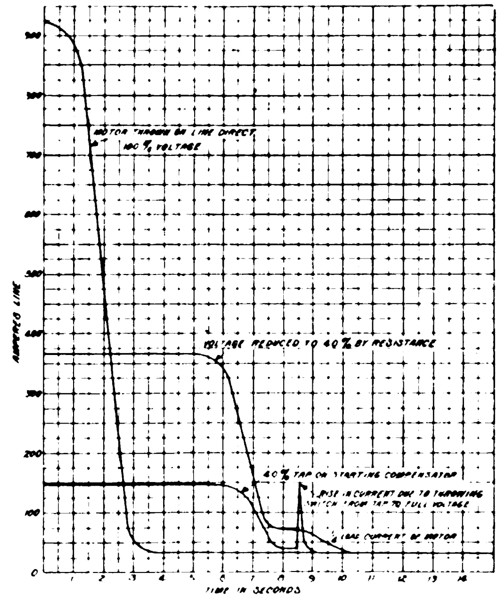
Curve 1

Starting of I-6-100-500-440 Volt Form K Motor with 100 per cent Load

(Rise at end of compensator curve is due to throwing switch from tap to full voltage)

The actual relation between the starting currents for a 100 h.p., 25 cycle, 440 volt motor, is illustrated graphically by curves No. 1 and No. 2, the former showing the current taken with the motor starting up with 100 per cent load, and the latter with about 25 per cent load. Both curves serve to show the decrease in the line current by the use of the compensator, but especially when starting the motor with no load or light load.

To fulfil the purpose for which the compensator is designed, the switch must be left in a starting position long enough to allow the motor to attain practically full speed. This usually requires from five to twenty seconds, and, at the end of that time, the switch should be thrown quickly into the running position. If the switch is thrown before the motor has attained speed, the current broken on the starting



Curve 2

Starting of I-6-100-500-440 Volt Form K Motor with 25 per cent Load

side, and the instantaneous current taken from the line on the running side, are much larger than when the full time allowance is given. The latter is also the case if the switch is not thrown quickly, as the motor must necessarily drop in speed during the time the switch passes from the starting to the running position. This therefore, not only defeats the purpose for which compensators are designed, but the excessive current is also detrimental to the switch.

Starting compensators are arranged in one of two ways, first, so that one reduced voltage may be applied to the motor terminals, and second, so that several successive voltages may be so applied. The former, or single tap compensator, is the simpler in construction, and is suitable for the majority of installations. The latter, or multi-tap compensator, has advantages only when the static friction of the load varies from day to day,, or for the starting of a *synchronous* motor operating under conditions that require very low starting torque and when it is desired to take advantage of this condition in avoiding undue line disturbances. Under these conditions a comparatively low voltage is required for starting and bringing the synchronous motor up to synchronous speed; then, by adjusting the field current to each increase in voltage, the current taken from the line in passing from the starting tap to the full line voltage is reduced to a minimum. As inferred, this method cannot be used to advantage where comparatively large starting torque is required, nor does it apply to the induction motor, in which machine field current adjustment is not possible.

The multi-tap compensator switch is usually arranged so that the movement of the handle is continuous, starting with the "off" position, and passing through the successive steps to the full voltage position. This arrangement allows an operator to throw the switch through the starting and into the running position in so short an interval that the motor will not have had time to start before full voltage is applied.

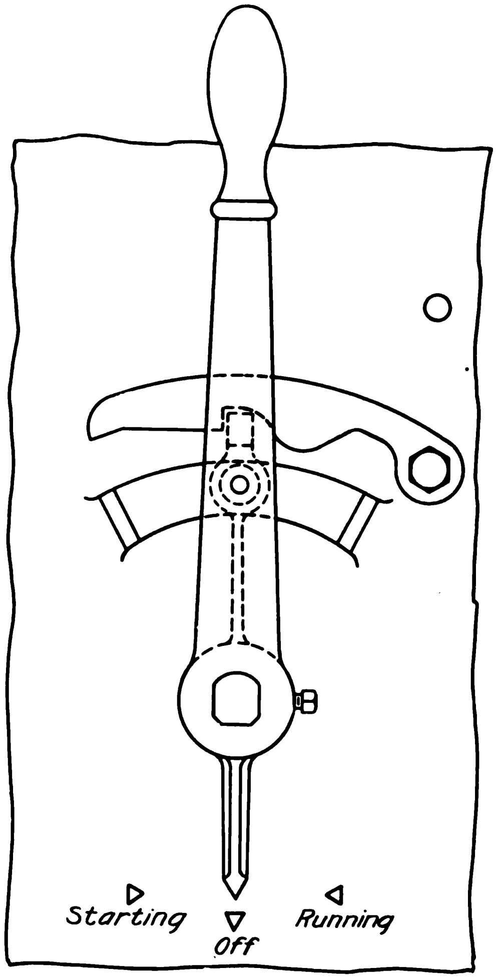


Fig. 2. Single Tap Compensator Switch with Latch

Also, because of the large number of contacts to be made at each point of the switch, a considerable amount of force is required to operate it, and, on account of the smaller angular distance between the various positions, the operator is likely either to throw the switch too far, or to operate it so slowly as to cause serious burning of the contacts.

In the single tap compensator, these

difficulties can be entirely overcome by arranging the switch so that the "off" position is in the center, the starting position at one extreme end and the running position at the other extreme of the throw of the handle.

By arranging the switch in this way, the operator has a positive stop at both the starting and running points, and he will be more likely to throw the switch full into the proper position, and leave it in the starting position a greater length of time than if the entire operation could be completed with one sweep of the handle. With a compensator arranged in this manner, proper operation is assured by the addition of a latch as shown in Fig. 2. This not only prevents the operator from throwing the switch into the running position before it has passed through the starting point, but also compels him to throw it over quickly, which reduces the burning of the switch contact and also lessens the momentary increase in the current taken by the motor when thrown from the tap to the line direct.

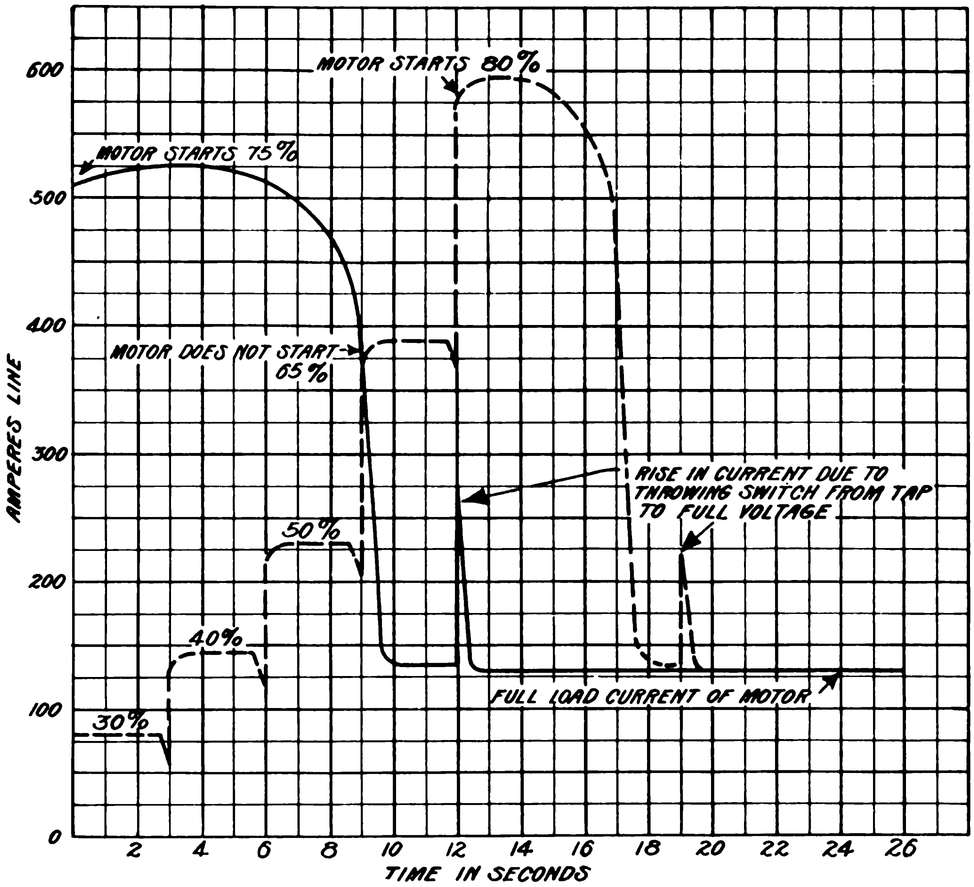
As previously stated, the design of the squirrel cage type of motor is such that no adjustment of any kind whatever can be made for the purpose of producing the best starting conditions, with the exception of that of the voltage applied to the motor terminals; and because of the inflexibility of the system, it is immaterial how this voltage is applied, the only requirement being that the voltage be sufficient to give the current necessary to overcome the static friction of the load. As no adjustment in the motor itself is possible, the application of any voltage below this is of no advantage in any way, except that it heats the armature winding, and by thus increasing the resistance, a slightly greater torque may be obtained. Furthermore, the characteristic of a well designed induction motor is such that the voltage necessary for starting is also sufficient to bring the machine to practically full speed without further increase, so that the application of an intermediate voltage between that necessary to start the motor and full line potential is of no advantage.

This conclusion, that there is no practical advantage in the application of a gradually increasing voltage to a squirrel cage type of induction motor, is shown by the curves and is the result of a series of starting tests which were taken with different load conditions on a 15 h.p., 60 cycle, 220 volt, three-phase motor, and on a 100 h.p., 25 cycle, 440 volt, three-phase motor, using multiple tap and single tap starting compensators of the proper size for each machine.

In this investigation, the compensators were connected in series with each other and between the line and the motor, while a graphic recorder was connected in series with one leg of the line. Six starting tests were taken for each condition of load, and with the best arrangement of compensator taps, one being tested while the other was cut out of circuit by throwing its switch into the running position.

The tests were taken with each compensator alternately, and the results on the 100 h.p. motor starting under full load conditions are shown in curve No. 3. A large number of tests under different load conditions were taken, but these shown are representative, and being taken with a comparatively large load on the motor, would be better suited to show the advantage of the multiplicity of starting taps, if any existed. A study of the curves will show, however, that the amount of current taken from the line to start the motor under a given condition of load is the same regardless of whether this voltage is applied gradually or instantaneously.

Attention is also called to the large currents which the switch of a multi-tap compensator is required to break. In the present instance, for a single start, the switch was required to rupture currents which were respectively 60, 110, 175 and 300 per cent of the full load running current of the motor, whereas, with a single tap compensator, the maximum current to be broken was but a trifle over full load current.



Curve 3
Starting of I-6-100-500-440 Volt Form K Motor with 100 per cent Load, Using Multi-Tap Compensator, and Single Tap Compensator
Multi-Tap Compensator, 30, 40, 50, 65 and 80 per cent Taps. Test Indicated by Broken Line
Single Tap Compensator, 75 per cent Tap. Test Indicated by Solid Line

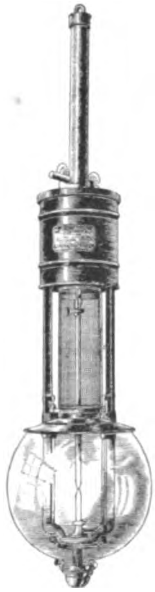
In the majority of installations of induction motors, however, the load to be started, and consequently the voltage necessary to start, is approximately constant from day to day, and a single tap compensator, or rather one having a number of taps, any one of which can be of the breaking of a much smaller current. selected for use, is therefore perfectly satisfactory after the proper tap for the particular installation has once been fixed upon.

The advantage of the single tap compensator can therefore be readily appreciated, as it is simpler in design and operation, and the desired results more likely to be obtained even when operated by inferior class of labor. The cost of maintenance is also reduced as not only are the number of ruptures of current decreased to a minimum, but the burning of the contacts and their renewal are also lessened, this reduction being in proportion to the decrease in the number of contacts, and therefore the number of ruptures of current, and also on account

ARC LAMPS

A. M. JACKSON

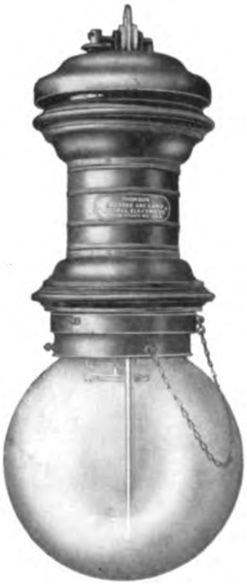
The Electric Arc Lamp has changed but little during the past fifteen years, the age of radical changes in the details of Electrical Industry; and although many developments have been made, such as the enclosed, series and multiple D.C. and A.C. Arc Lamps; from the Open Carbon Arc Lamps of about fifteen years ago to the present refinement of the 150 hour Enclosed Lamp, changes have been more or less confined to mechanical improvements.



Open Carbon Arc Lamp

About ten years ago it was found that by enclosing the arc, the life of the carbons was considerably increased (about ten times); it was also found that an arc at practically twice the voltage could be maintained, allowing the economical use of a single lamp on the standard multiple circuit of 100 to 125 volts. Nor was this all, for other advantages such as softer diffusion, improved distribution and steadiness, made themselves at once apparent over the unsteady glaring light of the Open Arc Lamp. These features have since been appreciated by a progressive public, who have learned that there is such a thing as quality in light.

These advantages were gained by surrounding the arc with globes, which unfortunately consume light, and it was therefore considered by many that light efficiency was sacrificed; this, however, is erroneous, if considering useful illumination, for the luminous intensity of the Open Arc varies so much with a low and frequent minimum, that any estimated average would show up in favor of the Enclosed Arc.



Enclosed Carbon Arc Lamp

Since about 1896, when the Enclosed Arc Lamp was first developed, it came rapidly to the front in replacing the old open arcs.

For a number of years past scientists and engineers have devoted their energies toward producing a lamp of still higher efficiency. It is a well known fact that light produced from incandescent solids is less efficient than that produced from incandescent gases, and in 1898 Bremer worked energetically along the lines of producing a light from incandescent gases, introducing, with more or less success, salts of the calcium group of elements into the electrodes of arc lamps. Since then a number of other lamps have been designed for the use of electrodes using various salts, the carbons of these being volatilized by the arc and the conducting gases rendered incandescent. These gases are of low resistance as compared with air, and consequently permit of the drawing of an arc of greater length than is the case when electrodes of pure carbon are used; as, with the pure carbon arc, the volatization being small, little gas is produced to act as a conductor, and hence the gap between the electrodes must be small and the carbons relatively close together. In the case of the carbon arc lamp only a small proportion of the light is developed from the arc itself, i. e., the incandescent gas, the greater part being given by the incandescent crater of the solid carbon; whereas in the case of the carbon containing salts of the calcium group, the light is almost entirely given off from the arc proper. These latter lamps are designated "Flaming Arcs."

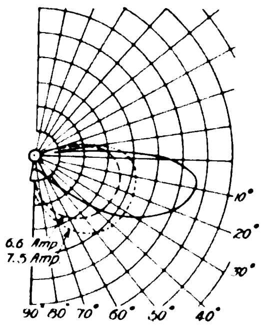
Some years ago, scientists employed by the General Electric Company found that an electrode composed of the magnetic oxide of iron, and other substances, produced a flaming, or more correctly a luminous arc, which was of high efficiency, steady, and of a color approaching that of daylight. These lamps have since been developed to a high state of perfection and several thousand are now used throughout this country and abroad. These lamps have been designated by the name "Luminous Arc Lamps." They are built in units sufficiently large to replace the old open arc lamps for street lighting with high economy of operation and maintenance, as the watts consumed are low and the life of the electrodes long, averaging 175 hours.

Flaming Arc Lamp

Not least of the many advantages of the Luminous Arc Lamp is its ideal distribution of light for street lighting purposes, as it gives a maximum of light at an angle of 10 degrees below the horizontal plane, the angle at which the light from the lamps overlap, when the distance between them is that usually adopted. This advantageous light distribution of the Luminous Arc Lamp is due to the fact that the light is derived from the vertical arc rather than from the crater, which latter throws its maximum light in the vicinity of the lamp.

These lamps are built to operate on both series and multiple direct current circuits. The series lamp as standardized by the General Electric Company consumes 310 watts at 4 amperes, and the multiple lamp 440 watts at 4 amperes.

The Flaming Arc, as referred to before, and as distinguished from the Luminous Lamp, has been introduced into this country from Europe, where it has been used with more or less success for commercial lighting in large cities. The lamps are designed for operation on constant potential circuits, usually two in series, on a voltage of 110 to 125. The light from them is particularly adapted to spectacular and advertising purposes. Although efficient from the standpoint of current consumption per candle power, the cost of maintenance of these lamps is high, owing to the high cost of the electrodes and their short life—about ten hours. The Flaming Arc Lamp is not well adapted to street lighting, as the maximum light is thrown in the vicinity of the lamp and also its intrinsic brilliancy is so high as to produce a blinding effect upon the eye, which has the result of making objects beyond the lamp appear by contrast less well lighted than is the case. This can be remedied in part by surrounding the arc with some globe which protects the eye from its direct rays, but this expedient materially reduces the efficiency of the lamp's illumination.



Curve Showing Distribution of Light from 4 Ampere Luminous Arc Lamp and Series Enclosed Arc Lamp

It may be noted here that the success of this type of lamp abroad is in part due to the higher cost of current, by reason of which its efficiency is an advantage, and the low cost of labor, which reduces the expense of maintenance. Another reason for its success in other countries, notably Mexico and Latin America, seems to be due to the disregard of the people of the blinding effect above mentioned, and also to the fact that they illuminate their streets very much more brilliantly than we do, which necessitates the use of many more lamps, with a much shorter distance between them, by reason of which the angle of distribution ceases to be a matter of serious consideration.

The Flaming and Luminous Arc lamps are not likely to replace carbon arc lamps for general interior lighting, except in the case of large machine shops, warehouses, and the like, as the character of the electrodes produces fumes which discolor ceilings, and such other surroundings as are above the lamp; but in buildings of this character the luminous lamp is to be recommended, on account of its efficiency and low cost of maintenance. In these cases, the lamps being hung high, are equipped with reflectors which throw the light in a downward direction. These reflectors are used inside of the globe, and therefore do not become coated with dust or fumes, which are frequently present in buildings of this description, and which would render the reflectors practically useless.

APPLICATIONS OF ELECTRICITY IN PAPER MILLS

Extract of paper read before the local Branch of the A. I. E. E. Feb. 14, 1907, by W. L. MERRILL

The following statistics, which are approximately as published by the Government for the year 1905, as compared with those for 1900, will give some idea of the magnitude of the paper industry in the United States.

Total capital invested, $278,000,000, an increase over 1900 of 66 per cent.

Total products of 1905, $188,000,000, an increase of 48 per cent.

There were 3,000,000 tons of paper produced in 1905, an increase of 66 per cent, which is equal to the increase in the capital invested. Of these 3,000,000 tons, 1,000 000 tons were for newspapers, an increase of 58.6 per cent; the remaining 2,000,000 tons were used for roofing, wrapping paper and the other various uses of paper down to cigarette paper.

During 1906, there were 161 mills producing ground wood pulp, 69 mills sulphite pulp, and 27 mills soda pulp.

During 1906 the factories of four of the major allied industries were divided as follows:

1100 devoted to the manufacture of boxes, 200 devoted to the manufacture of bags, 200 devoted to the manufacture of envelopes, 75 devoted to the manufacture of printing and wall paper.

The large number of box factories is probably due to the necessarily high rate of freight on such a commodity; therefore, it is necessary for box factories to be established for local consumption. There is, however, a noted increase in the establishment of folded box factories. The machinery for making these is very similar to the common types of platen presses, and the same requirements of drive are demanded.

Practically the same problem is met in the electric drive for paper making machinery as in other classes of mill work. In the past it has been the general feeling that an electric drive could be applied to any machinery or group of machines regardless of the layout, and to a very great extent this is true. There are a great many cases where mills are to be changed over to the electric drive where this method must be followed, but in new layouts, engineers are coming more and more to realize that the whole mill should be designed with a consideration to give the best economy and ease of operation, by considering the electric drive an integral part of the machinery. The machines to be driven should not only be arranged for a convenient and economical output from the machines themselves, but also, a convenient and economical installation of the electric drive. There are two methods which may be followed in any class of electric drives. One is to find the h.p. required to drive a given machine, supplying a motor of sufficient capacity. The second way is to study the customer's conditions and make a layout such that it will be necessary for his competitor to not only change to electric drive, but to the up-to-date drive. In general, this last method requires individual engineering for each class of work, but the experience gained in any given installation can be readily adapted to the next. In other words, the electrical engineer following this class of work, should place himself in the position of the mill owner or operator. He should study the conditions as they are, not only in operating the machinery, but as to what the man wishes to accomplish. After he has become familiar with the conditions that the particular class of mill is designed to meet, he can then see where the proper applications can be made for the electric drive, and I think in the near future the electrical engineer will not only be consulted when it is necessary to supply electric drives, but also in the first design of machinery for any class of work, or for the improvement of old machinery, in order that the combination of a given machine with a direct connected motor may work to the better advantage of both. This has been demonstrated beyond question by the large number of machine tool manufacturers throughout the country who have adopted standard electric motors for their machines when possible, and have had special machines developed for direct connection when the standard motors on the market would not meet the conditions.

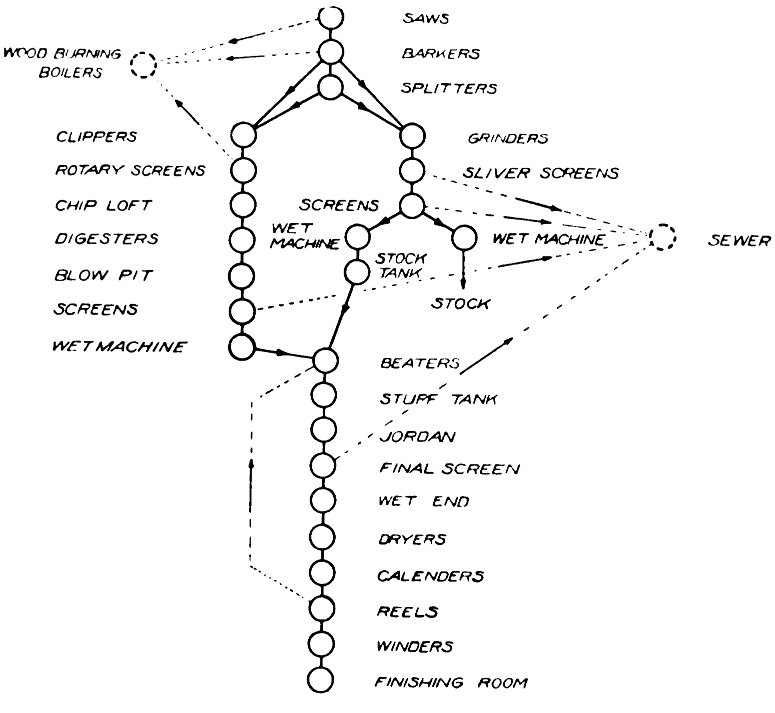

SAWS
WOOD BURNING BOILERS
BARKERS
SPLITTERS
CLIPPERS
GRINDERS
ROTARY SCREENS
SLIVER SCREENS
CHIP LOFT
SCREENS
WET MACHINE
DIGESTERS
WET MACHINE
SEWER
STOCK TANK
BLOW PIT
SCREENS
STOCK
WET MACHINE
BEATERS
STUFF TANK
JORDAN
FINAL SCREEN
WET END
DRYERS
CALENDERS
REELS
WINDERS
FINISHING ROOM

Fig. 1. Diagram Representing Combined Ground Wood, Sulphite, and News Mill

Figure 1 is a diagrammatic representation of a combined ground wood, sulphite, and news mill. Either one may be found in different parts of the country operating independently, or any two of the three may be found operating together, and in large mills we find a combination of the three separate mills.

Starting with the saws, the several operations necessary to produce a finished roll of paper are as follows:

The logs are sawed into the proper lengths for convenient handling and are then carried to the barkers, where the bark is removed. At this point the bolts are sorted, part going to the ground wood or mechanical process, the remainder going to the sulphite or chemical process. Bolts for the ground wood department, which are too large to be inserted into the grinders, are usually quartered by the splitters. Large knots are also split out of the bolts which are to go to the sulphite department.

The ground wood process is as follows: The bolts are placed in pockets and held against a large fluted grindstone by hydraulic pressure. A liberal amount of filtered water is continuously run on the stones to keep them cool and to sluice the pulp from the grinders to the silver screens, which remove any large pieces which may have worked their way into the stock from the grinders. It is then pumped to suction or centrifugal screens which sift out any grains of fiber which are too large for use in making paper. From the screens it runs to wet machines, which are of two classes. One prepares the pulp for immediate use in the beaters, by draining off all of the water not needed to facilitate pumping the stock to the beating engines. It is then run to the stock tank, where it is supplied to the beating engines by pumps as desired. The other class of wet machines draws out all the water possible, leaving the pulp so that it can be stacked for future use, or for immediate shipment.

In the sulphite process, the bolts are first fed to the chippers at an angle of about 45 degrees; here the rotary knives reduce the bolts to chips the size of one's thumb nail. These chips are then carried to rotary screens, which sift out the pieces too large for use in the digesters, and any small knots in the wood are reduced to very small particles by the action of the chipping knives. They are readily sifted out in the same screen. Chips are then carried to a chip loft, where they are stored for use in the digesters. After the digester, which holds several cords, has been filled with these chips, sodium sulphite, which has been prepared by burning sulphur, is mixed with the chips. The digester is closed, and live steam is applied for several hours until the combined action of the sodium sulphite and steam reduces the chips to pulp. The steam is then shut off and the pulp is drawn into the blow pit where the liquor is allowed to drain off. It is then washed with filtered water and pumped to the screens, then to the wet machines in a similar way to the process described for the ground wood.

The ground wood and sulphite pulp are then mixed in the beating engines with an amount of clay, resin and coloring. From the beating engines it is sluiced into stuff tanks, where a continuous supply is fed to the paper machines. This stuff tank is necessary, as the beating engines work periodically. From the stuff tanks, the stock is pumped or run by gravity to the jordans or refining engines, where it is still further ground to a fine homogeneous mass. From the refining engines it is pumped into several screens, similar to the ones already described, for the final screening before reaching the wet end of the paper machine, and is now a milky liquid with the particles of pulp carried in suspension. From the final screens the stock is run to the wet end of the machine, which consists of a fine wire mesh passing over rolls. The water runs through the mesh, leaving the pulp on the wire. Just before the pulp leaves the wire, it passes over some suction boxes in which a partial vacuum is maintained to still further reduce the amount of water. Stock is then collected on a roll, which in turn passes it to a felt, which delivers it to the driers, and it is carried over a large number of rolls filled with steam. From the driers it is passed through the calenders, which gives it the proper finish, and from the calenders it is wound on reels, one winding the paper, while the paper is being unwound from the other by the winders. Between the reels and the winders are rotary knives, which trim the edges of the paper and cut it to the desired width.

It is then ready for the finishing room, where it is prepared for shipment.

By further reference to the diagram, it will be noted that the refuse from the saws, barkers and rotary screens, is taken to wood burning boilers, which are usually run in multiple with the coal boilers. The residue from the screens is sluiced to the sewer, while the edgings from the reels are carried back and again reduced to stock in the beating engines.

Regarding the electric drive for the several departments, the following points will be found useful in the layout of a new mill, or in changing over an old mill to the electric drive. The logs on the saw-deck are usually handled by chain conveyors from the pond, while they are transferred laterally from this conveyor by "pneumatic kickers". Since the work of these "pneumatic kickers" is intermittent, the most economical installation would be an electrically driven compressor supplying air to a tank, which would be automatically started and stopped as demands required, similar to the air brake system generally used. The advantage of this over the continuous running steam compressor, which wastes air when the demand is not equivalent to the supply, can readily be seen. There is a comparatively recent development in the splitter which works either by compressed air or steam. The supply for running this kind of a splitter could be taken from the same tank as the log kick. An electric compressor of this type would require very little attention compared with the continuous running steam compressor.

The fan effect from the barkers is utilized in delivering the refuse to the conveyors which carry it to the wood burning boilers. If it is necessary to install the motors driving the barkers and saws where there is apt to be saw-dust and flying particles, the motors should be housed in, with the shaft protruding through the wall, so that water or saw-dust could not be carried into the motor compartment by the belt.

As the machinery for supplying chips for the sulphite department may or may not be run in conjunction with the machinery which supplies bolts for the ground wood department, it should be driven by a separate motor, thus avoiding the use of idlers, pulleys, etc.

As the location of water power usually determines the location of the mill, and in many cases the logs are transported to the mill by water, the grinders usually run direct connected to water wheels. These could be run by motors if occasion required; for example, several small water powers on a stream might be electrically developed and the power transmitted to one mill.

In the question of direct connection of individual motors to screen room apparatus, the following points should be considered. As the grinder and screen rooms are run as one operation, it will at once be seen that a shut down from any cause in the screen room will necessitate a corresponding shut down of the grinder room. Any application which could be made to the screen room to avoid a shut down would at once be appreciated by the operators. Of course, the elimination of shafting and belting would hold true in this work, as in any other, and as this point has already been discussed in numerous articles, there is no further need of discussing it at this time; but there is one difficulty met in the counter-shaft and belt drive in the screen room which is probably met by only a few industries, that is, the shutting down to take up or to replace worn belts. In the machine shop practice and other kinds of mill work, these changes can be readily accomplished at the noon hour or some other regular shut-down of the machinery, but as in the grinder and screen rooms the operation is continuous day and night, it becomes necessary to make arrangements for periodic shut-downs to look after the belting. This would be eliminated by supplying individual motors to the screens and wet machines, and could especially be adapted to the centrifugal type of screen, where the motor could be placed at the top. The difficulty in installing a large number of small motors in a moist locality could be very readily met by supplying enclosed motors and piping a small quantity of water to the frame, (as internal cooling coils would not be required), thereby reducing the size of the motor.

Motors used in the chemical preparation, such as gas pumps and motors for pumping liquor for filling the digesters, should be installed away from the fumes of the sulphur burners, if such may exist, and should also be protected from any accidental overflow from the digesters, for, unless especial provision is taken, it will find its way to the motor, either by running directly to it, or by being carried and sprayed over the motor by the belting.

It is a great convenience in operation if the pump or motor used for supplying liquor to the digesters is fitted with two points of control, that is, capable of being started and stopped by the man at the top of the digester.

A hand control of the digester valves and valves admitting steam to the digesters, has universally required the services of one to four men, according to the size of the valves to be handled, every time the digester is blown off. Before the main digester valve is again closed, it is necessary that the valve be taken apart and cleaned, and suitable provision is always made to accomplish this.

The ideal control for electrically operating these valves would be a controller located at the top of the digester house, which could be operated by the cock closing the steam valve and opening the digester valve. Some suitable travelling nut could be supplied which would turn off the current at the motor when the digester valve was opened and the steam valve was closed. There should also be supplied a controller for operating these valves locally, as this would greatly facilitate the cleaning and closing of the digester valve. If motors are to be installed for this work, the same precaution should be taken as mentioned above for motors used in connection with the chemical process, and it would undoubtedly be found feasible to locate the motors at a considerable distance from the digesters themselves with suitable mechanical connection.

The question of eliminating belting from the beating and refining engines should be considered. An installation has already been made with a motor direct connected to a refining engine, as the adjustment of the refining engine is accomplished by moving a cone backward and forward, the motor was mounted on a bed-plate supported by rollers. This method of direct connection should give very satisfactory operation. The question of driving the paper machine electrically has to be considered for each individual case. For constant running news machines, that is, machines where practically no variation in speed is required, it has been found very satisfactory to drive the machines by engines using the exhaust in the driers. Where a large number of machines are installed, a great many prolonged shut-downs, due to the breaking of an engine, could be eliminated by supplying an extra pulley on the counter-shaft and having a portable motor which could be connected up in a very few minutes to any machine in case of accident to the engine.

For driving the paper machines where variable speed is required for obtaining different thicknesses of paper, the speed control offered by the Ward Leonard system is giving very satisfactory results where a large range is required. Smaller ranges could be taken care of by variable speed AC and DC motors as occasion might demand.

A large number of centrifugal pumps and conveyors are required in this class of work, but their application is so varied that individual engineering will be usually required for each application.

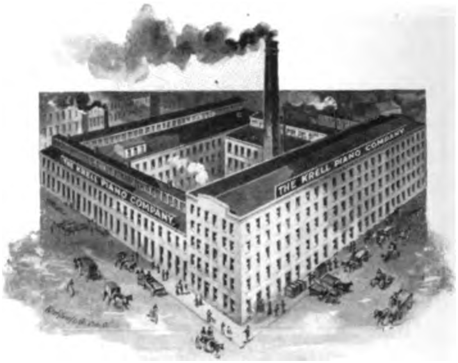
Regarding the layout of circuits for power distribution in large mills, there are two systems which can be followed. First, running all the circuits from the switchboard to each department. Second, running main feeders from the switchboard to each department and installing a distribution board. This last reduces the cost of installation and minimizes the number of circuits to give trouble from mechanical injury, but on the other hand, where only one circuit to a department is used, if anything happens to this circuit the whole department is shut down.

The system of lighting which has been found very successful in mill work, is as follows. Running the arcs and incandescents from transformers fed from the main generating station and running auxiliary feeders from the exciter panel to each distribution board, and installing a double throw switch in each distribution board so that the incandescent lights can be thrown on to the direct current circuit if a fuse should blow in the lighting transformer; or, if for any reason the mill were shut down, it would only be necessary to run one of the exciters to give sufficient light for repairs.

DATA ON MOTOR INSTALLATION, THE KRELL PIANO CO., CINCINNATI, OHIO

By L. T. Rainey

This data, while not new to all, may be of interest to those in the selling organization, who are continually quoting on similar propositions.

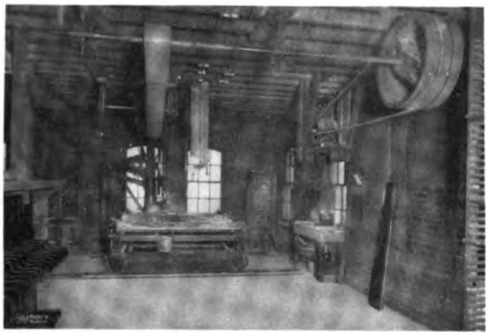


The Krell Piano Works, Cincinnati, Ohio

In the Krell Piano Co., owing to an accident occurring to the main driving shaft, the original plant (which was driven by a 200 h. p. engine through rope transmission) was put out of commission, all the defferent departments being shut down.

Back Dressing Machine Belted to a 25 h. p. Induction Motor

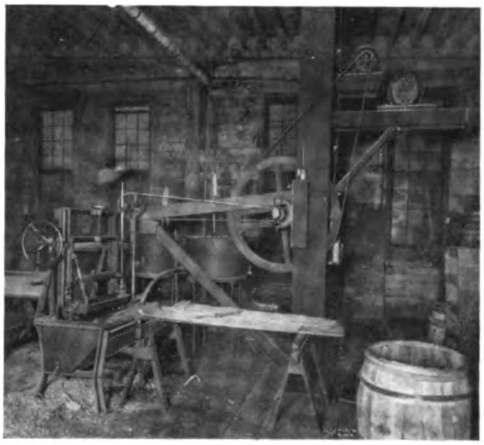
The Krell Co. immediately called upon the General Electric Co. for motors, leaving it to the latter to select the proper sizes necessary for driving the different departments. It was estimated that they should install two 35 h.p., one 25 h.p., two 10 h.p., two 7½ h.p., one 5 h.p., two 3 h.p., one 2 h.p. and one 1½ h.p. motors, to drive the different groups given below. All the machines were form "K", 3-phase, 220 volt, 60 cycle, moderate speed induction motors. The order was secured as above, and the motors were installed and running within three days from the date of the shut-down.



Group 7 Rubbing Machine Belted to a 3 h.p. Induction Motor

After the installation of the above motors, accurate tests were made to determine the actual horse power necessary to drive each group. Below is given the number of machines, average hours per week, maximum estimated horse power per machine, and the actual horse power delivered by the motors installed on each group.

The column headed "Maximum Horse-Power" was obtained by calculation from data furnished by the builders of the different wood working machines. This information, therefore, can only be used for estimating purposes. It can readily be seen, however, by comparing the items in this column with those in that headed "Motors Installed", that the load factor is very low in this class of plants. The last column headed "Actual H. P. to Drive" was the result of tests, and the data obtained will be found to agree exceedingly closely with the size of motor installed.



Large Glue Spreader Belted to 1/2 h. p. Induction Motor

The class of material used in pianos is all hard woods, such as 2½ inch Poplar, 1¼ inch Spruce, 2 inch Hard Maple, 2 inch Mahogany, 2 inch Ash, and 2 inch Walnut.

MILL ROOM—FIRST FLOOR

Group No. 1

No. Machines.	Name of Machine.	Average Hours per Week.	Maximum Horse Power.	Motors Installed.	Actual h.p. to drive Group.
1	Knife Grinder—500 r.p.m.—tight & loose pulley 8 x 3 1/2, Fay & Egan Co.	10	5	10	8.5
1	Boring Machine, tight & loose pulley 8 x 3 1/2-900 r.p.m.—F.&E.	40	9		
1	Stippling Machine—325 r.p.m., tight & loose pulley 10 x 2 1/2		2.9		
1	Grinder, 630 r.p.m., pulley 12 x 3 in.	10	8		
1	Wonder Sander (Racing-Wis.) size No. 1—1450 r.p.m.—4 x 6	20	12		
1	Iron Table Saw Circular, 2700 r.p.m., pulley 4 x 5, Fay & Egan	30	18		
1	Iron Cir. Saw Cordesman, Cin'ti., 2800 r.p.m.—pulley 4 x 5 in.	30	18		

Group No. 2

No. Machines.	Name of Machine.	Average Hours per Week.	Maximum Horse Power.	Motors Installed.	Actual h.p. to drive Group.
1	Woodworker, Bentle & Margedant, 3600 r.p.m.—pulley 5 x 5	30	30	35	30
1	Tenoning Machine, tight & loose pulley 11 x 5—Fay & Egan	10	3		
1	Frizzer, pulley 10 x 5 1/2, F. & E.	59	15		
1	Drum Sander, F. & E.—pulley 13 x 10, 750 r.p.m.	59	10		
1	Band Rip Saw, F. & E., 1500 r.p.m.—pulley 20 x 6	30	23		
1	Band Saw, F. & E.—700 r.p.m., pulley 20 x 8	5	37		
1	Planer (large) counter shaft speed 975 r.p.m.—pulley 24 x 6	20	42		

Group No. 3

1	Sticker (small) J. O. Colloday, Phila. 1050 r.p.m.—pulley 8 x 5	10	10	35	Maximum 44 Average 24
1	Sticker (large) Rowly & Herman, Williamsport, Pa., 1000 r.p.m.—pulley 12 x 8	50	12		
1	Glue Jointer, Fay & Egan—900 r.p.m.—can use any size pulley	40	18		
2	Hand Planers—4000 r.p.m.—pulley 4 x 6	59	3		
1	Double Cut-off Saw, F. & E., 940 r.p.m.—pulley 10 x 6 in.	40	25		
1	Wood Trimming Circular Saw—2650 r.p.m. pulley 4 1/2 x 5	40	10		
1	Wood Rip Saw, 2500 r.p.m.—6 x 6	35	25		
1	Elevator, counter shaft speed 350 r.p.m., provided with tight and loose pulley				
1	Planer (small), counter shaft speed 1100 r.p.m.—pulley 24 x 6	20	45		
1	Planer (medium) with counter shaft speed 1050 r.p.m.—24 x 6	20	42		

Group No. 4

1	Band Saw, F. & E., 450 r.p.m.—pulley 14 x 4 1/2	59	14	7.5	6
1	Jig Saw, F. & E.—pulley 5 x 4 1/2	30	2		
1	Dowel Machine, F. & E., counter shaft 750 r.p.m.—pulley 13 in. diameter, machine pulley 5 in. diameter, 1945 r.p.m.	1	3		
1	Turning Lathe, 2400 r.p.m.—cone pulley 4 in., 6 1/4 in. 12 in.	59	12		
2	Swing Saws on one counter shaft, 640 r.p.m	40	10		
1	Rip Saw, 3200 r.p.m.—Fay & Egan--5 x 5	59	25		
2	Small Glue Spreaders	59	1/2		

Group No. 5

1	Pin Boring Machine, F. & E., counter shaft speed 720 r.p.m.	35	2	5	5
1	Sand Wheel--300 r.p.m.	30	2		
1	Maddox Sander—Jamestown, N. Y., 100 r.p.m.--tight & loose pulley 11 1/2 x 4 1/2	30	2		

SECOND FLOOR (ACTION FINISH DEPARTMENT)

Group No. 6

No. Machines.	Name of Machine.	Average Hours per Week.	Maximum Horse Power.	Motors Installed.	Actual h.p. to drive Group.
1	Band Saw, F. & E.—600 r.p.m.—tight & loose pulley 12 x 3 1/2	20	9	3	3
10	Key Boring—820 r.p.m.—pulley 4 5/8 x 2 1/4	40	3		

RUBBING ROOM—SECOND FLOOR

Group No. 7

1	Rubbing Machine, counter shaft speed 80 r.p.m.—machine speed 45 to 60 r.p.m.	50	3	3	3

KEY DEPARTMENT—UPPER GALLERY

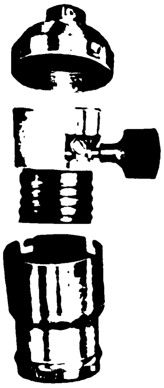
Group No. 8

1	Block Sander—75 r.p.m., pulley 36 x 3	30	2.9	10	5
1	Circular Saw, 3200 r.p.m.—pulley 3 x 4	25	9		
1	Sand Wheel, 1235 r.p.m.—pulley 5 x 4 1/2	35	10		
1	Band Saw, Crescent Machine Co., 520 r.p.m.—tight & loose pulley 12 x 4 1/2	59	1		
1	Mortice Machine, 170 r.p.m., pulley 10 x 3 1/2	30	1.9		
1	Boring Machine, 1500 r.p.m., tight and loose pulley 8 x 4 1/2	30	19.3		
1	Buffing Machine, 1150 r.p.m., pulley 3 3/4 x 3	40	4.8		
1	Sand Wheel (large), 900 r.p.m., pulley 8 x 4 1/2	40	11.5		
1	Small Ivory Sand Wheel, 900 r.p.m., 4 1/2 x 3	30	4.3		
1	Ivory Sand Wheel, 950 r.p.m., pulley 7 x 3 1/4	30	8.5		
1	Elevator for hauling finished pianos, counter shaft speed 200 r.p.m.--tight and loose pulley	40	Maxim. Load 7 1/2	7 1/2	8.7
1	Sturtevant Blower Fan, 2 "inlets" and one "outlet"			25	30.5
1	Back Dressing Machine, Bentle & Margedent	20	—	25	—
1	Rip Saw	20	—	2	2
1	Large Glue Spreader	50	—	1/2	1/2

THE "SECURITY SNAP" SOCKET

J. G. DALLAM

Among the recent developments of wiring supplies by our Supply Engineering Department the most noteworthy is the "Security Snap" Socket. This is an improvement in the Standard Edison Base Sockets which will doubtless prove an important one. It is a new feature in the method of holding the outer parts of the sockets together.



Parts ot Security Snap Socket
Showing the Three Bayonet Joints

The bayonet joint connection in the shell and cap, which has always been one of the strong features of our standard socket, is retained and added to by inserting a third joint so as to secure a perfectly rigid connection, while in place of the screws which have heretofore been used to clamp the shell and cap together, an automatic catch or lock has been provided.

As in all improvements in wiring appliances, the primary objects from an engineering point of view, are safety and simplicity, and the advantage from the user's point of view is the time saved. It can readily be seen that this latter point has also been gained, as wiremen will be able to handle these sockets much more rapidly than the present standard.

In the manufacture of electrolier fixtures where the use of husks is becoming more general every day, this socket also fills a long felt want. The husk is the ornamental part of the fixture which fits over and completely conceals the socket, and in many instances, the space within the husk is brought down to a minimum, so that this socket shell, which can be placed in the husk without the use of tools, is especially adaptable to this purpose. In some cases it becomes necessary to remove the socket from the husk, and this can be done very easily without bending or spreading the latter.

Method of Assembling Socket

COMPARISON OF THIRD RAIL AND OVERHEAD TROLLEY CONSTRUCTION AS APPLIED TO THE ELECTRIFICATION OF STEAM ROADS

By C. E. EVELETH

At best, the secondary distributing system, used to transmit the energy to the moving trains, must be looked upon as a burden in the operation of the converted road which is entirely foreign to its operation by steam locomotives. A comparison, therefore, of the various types of construction to aid in selection of a system must show, not their relative advantages, but their relative difficulties.

In the three columns below are given some notes collected to show the relative disadvantages of the third rail, and high tension overhead trolley in the operation of a steam road converted to an electric road.

The high tension trolley has been divided into two groups, one represented by three or four track heavy bridge construction with 300 ft. spans, and the other using wooden or iron poles with side brackets, or span construction. Column No. 1 refers to a four track protected third rail system, No. 2 refers to a high tension bridge catenary construction, and No. 3 refers to a high tension catenary pole construction of the side bracket or cross span type. No attempt has been made to list the advantages of the electric systems over the steam systems, nor has a balance been made of the relative costs of the electric systems. These two questions should be considered separately, as the points taken up in these notes refer only to the relative difficulties encountered in the three systems.

Since a balance or actual comparison can only be made numerically, numbers have been placed after every item which may, for convenience, be said to represent units of difficulty.

RELATIVE DISADVANTAGES

I Protected Third Rail.		II Overhead High Tension Bridge Catenary Construction.		III Overhead Side Bracket Catenary Construction.	
A. Interference with track maintenance	3	Entirely clear of road bed....	0	Same as II..................	0
B. Can be maintained by section gang	1	Requires special tools, crews and work trains............	5	Same as II, but not as important	2
C. Easily cleared up and insulated when derailment occurs	1	In the way of boom of derrick car—liable to be knocked down and put all tracks out of service	3	Same as II..................	3
D. Hindrance to coupling freights, etc. With protected rail this is not very serious	2	Dangerous to freight brakemen on account of parts hanging down and small bridge clearance. Very difficult to install satisfactory ticklers to warn trainmen when approaching bridges..	4	This point is of less importance	1
E. Interference with clearing snow between tracks...	1	Not effected	0	Not effected	0

RELATIVE DISADVANTAGES (Continued)

	I Protected Third Rail.		II Overhead High Tension Bridge Catenary Construction.		III Overhead Side Bracket Catenary Construction.	
F.	Ease of satisfactorily collecting current on account of location, where relative motion between track and rail is small. Collectors may be safely replaced on the road...	1	Difficult to collect current, as a more complicated mechanism is required on account of the grade of the wire due to low clearances at bridges and high clearances at road crossings....	5	Similar to II................	3
G.	May be readily inspected by track walker.......	1	Requires a man with special training	3	Similar to II, but of less importance	1
H.	Life of conductor long..	0	Life of conductor and cables comparatively short on account of wear and deterioration due to gasses from freight locomotives and work trains. Should estimate that the entire railroad will be out of commission two or three per cent. of the time after the first five years	4	Life of conductor reasonable.	2
I.	Ease of sectionalization. Jumpers may be disconnected at the nearest adjacent road crossings	1	Difficult of sectionalization...	3	Sectionalization not of so much importance	1
J.	May be worked on while alive to make track changes or repairs, making system very flexible	1	Requires that current be shut off no matter how slight repairs are, making system inflexible	5	Similar to II, but not of such importance	3
K.	Work trains can run out on power from the rail	0	Must have independent source of power such as gas or steam	2	Same as II.................	2
L.	No interference with vizual signals	0	Signals located and seen with difficulty, as they must be lower than the bridges and even then have the distant bridges as a background. Dangerous to maintain signals in this location, as it must be done from ladders.	5	Not effected	0
M.	Danger of wreck from burning off track rail due to arcing current. This is a possible contingency, but one not very likely to occur....	1	Danger from dangling overhead work when messenger cable is burned off at a defective insulator	1	Same as II.................	1
N.	Little interference with fire extinguishing apparatus in the car storage yard	0	Difficulty in removing cars on account of high tension interfering with firemen...	1	Probably will have low tension for this work..........	0
O.	Absolute freedom from lightning disturbances.	0	Very much exposed to lightning	2	Same as II.................	2

RELATIVE DISADVANTAGES (Continued)

	I Protected Third Rail.		II Overhead High Tension Bridge Catenary Construction.		III Overhead Side Bracket Catenary Construction.	
P.	Entire freedom from telephone and telegraph disturbances, also inductive effects on signal wires	0	Difficult, as yet unsolved problem in connection with these interferences, affecting not only the Railroad Company's wires, but those belonging to other interests. "Unsolved" should be interpreted to mean at moderate expense	2	Same as II	2
Q.	No trouble at grade crossings with crossing trolley wires	0	Probably trolley crossings will have to be avoided by overhead or undergrade crossings	2	Troubles similar to II	3
R.	Can add sidings or more tracks with little difficulty	1	Can make such additions only at considerable expense	3	Difficulty not very great	1

The totals of these three columns give the following interesting results:

1. Third Rail (protected)	14
2. Overhead high tension bridge construction	50
3. Overhead high tension side bracket or span construction	27

It should be borne in mind that these figures are not based on any absolute figures. They do, however, indicate to a certain extent the relative difficulties of the systems.

In round numbers, the costs per mile of the various constructions are about as follows:

1. Third Rail (protected)	$5500.00
2. Overhead high tension bridge construction	6500.00
3. Overhead high tension side bracket or span construction	3500.00

These values indicate that in many instances, the increased difficulties encountered with system number 3, as compared with number 1, may be more than offset by their relative costs.

It would also appear that there must be other reasons than those of economy and freedom from difficulty in operation on the particular section of the road where system number 2 is used.

OBITUARY

In the death of George A. Brebner on Feb. 21st, the General Electric Company lost one of the ablest among the younger members of the Engineering Dept. His sudden death which resulted from internal injuries received in a coasting accident on February 16th, came as a great shock to all of his associates.

Mr. Brebner entered the General Electric Company in 1897, and at the time of his death was employed in the Power and Mining Engineering Department.

His sterling character and high order of ability challenged the admiration of all who knew him and gave him many warm friends who sympathize with his family in their affliction.

NOTES

Mr. J. J. McCann, who for the past sixteen years has been employed in the Supply Department of the General Electric Co., tendered his resignation to accept the position of Asst. Purchasing Agent for Messrs. Stone & Webster, Boston, Mass. At the time of leaving he held the position of Chief Clerk.

* * *

Mr. A. S. Kappella, of the Railway Engineering Department at Schenectady, was married in Philadelphia on Thursday, February 21st, to Mrs. Stella P. Hayes of that city. Mr. Kappella is Treasurer of the Local Branch, American Institute of Electrical Engineers, and has been one of its most active members.

* * *

Mr. C. C. Chesney has been appointed Manager of the Pittsfield Works of the General Electric Co., formerly the works of the Stanley G. I. Electric Mfg. Co.

Mr. J. R. Buchanan has been appointed Assistant Engineer of the Philadelphia office.

* * *

Mr. L. G. Crawford has been appointed Assistant Engineer of the Chicago Office, in place of Mr. Whitehurst, who has resigned.

* * *

Mr. P. M. Lincoln, in his article on Alternating Current Generators in the December issue of the Electric Journal, makes the following remark in regard to Automatic Regulators:—

"There are on the market a number of automatic devices which operate to change the field strength of a generator in response to a change in generator voltage. The most successful of these is, without doubt, the Tirrill Regulator now being manufactured by the General Electric Company. This device operates by regulating the strength of the exciter field and uses the change in exciter voltage to oppose the main voltage, thus preventing overrunning. This regulator has been very extensively used and has given almost universal satisfaction."

* * *

The annual meeting of Chicago Office salesmen was held at the Grand Pacific Hotel during the week of January 7th. A number of representatives from Schenectady were present to discuss various branches of engineering and commercial work.

Mr. W. J. Foster gave an interesting talk, illustrated by lantern slides, on The Design and Construction of A.C. Generators.

Mr. W. S. Moody was also present, to answer many pertinent questions asked by the salesmen, regarding high voltage transformers of large capacity.

Mr. W. L. R. Emmet was present at the dinner given on Thursday evening, and spoke of the recent progress in steam turbine developments.

After the dinner on Monday evening, an innovation was introduced which proved very popular. Mr. Vaughen was to speak on Instruments, and as a preliminary, Mr. Sunny suggested that he be asked questions upon the subject. This was done, and Mr. Vaughen devoted the greater part of the evening to their answer.

In this manner the information which was most needed by the salesmen was brought out. The idea became so popular that the same plan was followed at the subsequent sessions.

Mr. M. O. Troy gave a very interesting talk on Transformers, Feeder and Generator Regulators, Lightning Arresters and Mercury Arc Rectifiers. The questions asked Mr. Troy by the salesmen indicate the importance of these devices and the interest the salesmen are taking in their exploitation.

Mr. W. D. A. Ryan spoke upon the subject of Illumination, laying special stress upon the advantages of the Light Balancing Diffuser Ceiling.

The salesmen were greatly interested in the new design of street bracket and reflectors for incandescent lighting, and predicted a very large demand for them.

Mr. F. W. Wilcox told of the advantages to result from the new factory facilities, which will make possible a largely increased production of lamps, and prompt deliveries. All were much interested in Mr. Wilcox's talk on the recent development in the Art of Illumination, especially in regard to the Tungsten lamp.

Mr. Callahan spoke upon the subject of Heating Devices, and gave a list of the new apparatus to be put on the market during the coming season.

Immediately after the fire, the San Francisco Office secured quarters by rapidly building a warehouse, of 40000 sq. ft., at Emeryville. This was used at first as a store house, but later, finding their office quarters inadequate, the Engineering and Supply Departments were housed there. A difficulty then arose, as no suitable lunch accommodations were procurable, so with characteristic enterprise a room in the warehouse was constructed and equipped for the purpose, and an informal organization, calling itself the "G. E. Lunch Club" was formed to defray expenses.

A surplus remaining in the treasury, an extra spread was given on the Saturday before Christmas. Mr. Russell arranged the menu, of which the following is a copy:

EMERYVILLE LONESOME PRECINCT
DECEMBER 22, 1906
Bill of Ladling

Calamity days are now things of the past
We live under genial skies;
We've forgotten the bread line
And now come to feast
In a warehouse chock full of supplies.

The stock of transformers and meters and lamps
By our cooks have been put to good use;
"Converted" they've been into edible things,
Transformed into all kinds of juice.

MENU

CELERY	The first on the list is "salary" boquet A la Kearney (served every two weeks)
WAREHOUSE SALAD	Then transil oil salad with excelsior mixed Is a dish that an epicure seeks.
PICKLES **Never Re-fused**	Then cartridge type fuses in 58 kinds Converted to pickles, you know To prevent over-loading till better things come Sort of fuses to make you eat slow.
TURKEY **Bronze Finish**	Then gaze on the fowl with his wadding of sage And forget that you e'er had to work: His wings iridescent are cooked incandescent Short lived but high candle power "turk."
MINCE PIE **Rubber-Covered**	Mince pie from NewEngland all made up in Lynn Of mica and rubber wrapped wire It was ordered in time to arrive at the feast Many moons before earthquake or fire.
SWITCH CHEESE AND COFFEE	Then switch from the cheese to the coffee at last Percolating as though in high glee We're happy to-day, but more happy to say We're under the roof of G. E.
TRIMMINGS **Assorted**	Bottom land corn raised by the elevator Chewing gum tape for splicing (Single people get some) Cracked nuts and insulators Electric currents raised from the plants.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Schenectady Branch

The February meetings of the Schenectady Branch of the A.I.E.E. were well attended, and the papers were of the usual high standard of excellence. The first meeting was held on February 7th and was devoted to the discussion of "Electrification of Steam Railroads".

The discussion was opened by Mr. W. B. Potter of the Railway Engineering Dept. of the General Electric Co., who gave an extemporaneous talk covering the essential features to be considered in railway electrification.

Mr. Potter first gave the reasons which decided the New York Central, the Manhattan Elevated and the Interurban Railroad, in favor of electrical equipment; the New York Central R. R. requiring it for use with the Park Avenue tunnel, the Manhattan Elevated in order to secure higher train speeds, and the Interurban Co. because the very nature of the Subway made steam equipment an impossibility. He stated that changes in motive power are made for the purpose of securing better financial results, and in this connection gave some interesting data regarding the gross receipts per mile of certain steam and electric railroads.

Attention was next called to a number of other points which become deciding factors in different cases, such as double tracking, tunneling, frequency of train service, etc.

The diversity of opinion among the different engineers and difficulty of arriving at accurate conclusions was touched upon.

He next discussed the recent developments in railway engineering, and their bearing upon the question of direct vs. alternating current, mentioning the use of the commutating pole as a solution of the problem of sparking even with high voltages. In regard to the single-phase motor, he spoke of the problem of frequency, as a matter for careful investigation, pointing out the advantage of ow frequency in producing greater draw bar pull, but stated that reduction is limited by the resulting increase in cost of generators and transformers.

He spoke of a rotary converter installed on the locomotive as having been suggested as a solution of the difficulty, but said that the operation might be interfered with by the making and breaking of the circuit due to ice on the conductor or other conditions that would pull the converter out of step, and said that an induction motor generator set operated better, but that with an induction motor, a low frequency was not advantageous.

Mercury arc rectifiers were next mentioned as being open to further investigation. Mr. Potter stated that all railway apparatus must be capable of withstanding "dead" short circuit and cited as other important considerations, the efficiency, cost of maintenance, and reliability.

He also said that the induction motor, in regard to the use of the third rail, overhead trolley, etc., and said that the problem of the conductor is as great as that of the system.

The effect of high voltage trolley circuits upon telephone and telegraph lines was also mentioned, the former being effected by magnetic induction and the latter by static induction.

He next compared the D.C. and the single phase motors for railway use, and showed that while the single phase motor, operating at high speed, closely approached the D.C. series machine, it was quite inferior at lower speeds, and deduced from this that though serviceable in long runs and few stops, it was unsuited for service where frequent stops are made.

The next speaker was Mr. E. F. Alexanderson, who stated that while reducing the frequency of a single phase motor would increase its power, that due to its pulsating flux, the output per unit weight would never reach that of a D.C. motor with its constant flux where the iron is saturated continuously.

He also said that the induction motor, although its application for general railroad work has been demonstrated abroad, will probably find use in this country only under special conditions.

A low frequency single-phase generating system while more expensive than a three-phase equipment, would operate successfully after once installed, whereas the trouble from the overhead three-phase construction is an unknown quantity.

He called attention to the fact that while one of the strongest claims made for the induction motor is its adaptability as a brake by returning power to the line, the single-phase motor can be made to operate in the same manner, and will act as a brake down to low speeds.

Mr. Alexanderson was followed by Mr. S. T. Dodd who spoke of the assumption in a recent paper that one electric locomotive will replace two steam ones. He quoted certain figures from the American Railway Master Mechanics' Association as to the distribution of time of a steam locomotive, and pointed out that while the electric locomotive would save the time lost in stopping for water and coal, many of the other items were common to both. He deduced from these figures that the actual gain in mileage for the electric locomotive over the steam, was only about 30 per cent. To double the ton mileage by longer or heavier trains, would require changes in sidings, bridges, etc., not taking into account in the paper, and to accomplish the double work by higher speed means still higher maintenance cost. Such considerations as these, Mr. Dodd said, showed that increased ton mileage is not to be anticipated without large additions to the "Capital Account" and "Fix Charges", or an increase in the "Operating Expenses" assumed in the paper.

The next speaker was Mr. W. I. Slichter, who said that in selecting a system, it was not a question of D.C. motor versus A.C. motor, each of which has its own field, but rather the balancing of the various cost factors, to gain the best results, that determines the decision. He then gave the items of cost in a 600 volt D.C. interurban equipment, and pointed out that the low tension line was the greatest of these. The natural way to reduce this expense would be to raise the voltage, and he called attention to the fact this has been the tendency of late, but said that 2000 volts is probably the limit for use on a motor.

This introduced the question of conversion and the use of an alternating current. Mr. Slichter said that while the single phase motor is more expensive than the direct current machine and is not its equal, it is still applicable in a system of this kind.

He then gave the cost items for an A.C. road of similar description, and showed that in addition to the reduction in copper, there was no need for rotary converters thus making a still further saving.

He then pointed out that while the preceding was true with regard to these interurban systems, the aspect of the problem is entirely changed when the system is to operate under denser traffic conditions, requiring a greater number of cars, as the increased cost of equipment would offset the saving in low tension transmission line and sub-stations. The fact was also mentioned that single phase sub-stations having no movable machinery, would require less attendants than the D.C., making a saving in this direction.

Mr. S. B. Fortenbaugh next discussed the freight problem assuming this to include passenger and miscellaneous train service, and stated that for proper consideration of the subject, it is necessary to have full details concerning road and traffic conditions, and while definite money saving is difficult to determine, the advantages accruing from increased speed, capacity, terminal facilities, etc., are the features gained. That while contrary to the general accepted opinion, the total expenses are not reduced a saving in operating expenses per unit of traffic being balanced by the increase in fixed charges, the earning capacity is increased. In demonstration of this, Mr. Fortenbaugh cited the case of the Manhattan Elevated Road, in which the cost of operation per car mile was only reduced from 12½ to 9½ per cent exclusive of interest, but the earning capacity rose from a four per cent dividend basis to a seven per cent or more, and this in spite of added competition.

The last speaker of the evening was Mr. C. E. Eveleth, who gave some valuable data regarding the relative disadvantages of the Third Rail and Overhead Trolley construction as applied to the electrification of steam roads. Mr. Eveleth's paper is given in full in this issue.

* * *

On February 14th, Mr. W. L. Merrill spoke upon the subject of Electric Drive for Paper Making Machinery. The lecture was illustrated by lantern slides, and the different processes in paper manufacture fully described. Mr. Merrill's paper is published in this issue.

On February 21, Mr. C. W. Stone read a paper on "A Comparison of the Different Systems of Distribution for Electric Lighting." We hope to publish this paper in a future issue.

On February 28th, Mr. W. S. Moody read a very interesting paper upon The Design of Transformers. Mr. Moody gave a synopsis covering the developments in transformers since their early inception to the present day. This paper has been received too late for publication in the current number of the Review, and will therefore appear in the April number.

QUESTIONS

This section is open to inquiries upon engineering subjects. The questions will be submitted to the respective departments and such as are of general interest will be answered in this column, while those of less importance will be answered by letter.

Q. The dialectric strength of insulation close to conductors subjected to high potentials is often strained beyond its limit, where the diameter of the conductor is small, without the breaking down of the cable: Does this strain gradually deteriorate the insulating qualities of the cable?

A. When the potential gradient at the surface of the conductor is greater than that permissible with the given amount of insulation, corona effect will occur to such a depth in the insulation as to correspond to the diameter of the conductor which would cause no corona effect. The insulation is thereby destroyed, but the destruction would only occur for a certain distance and stop there, provided the insulation did not contain any moisture or chemical which might form nitric acid or some other destructive combination. E.J.B.

Q. Trouble has occurred in England on the coils of alternators wound for high potential work due apparently to the formation of ozone which has the effect of forming nitric acid on the insulation with deleterious results. Does this determine to any extent the limiting voltages for which alternators may be wound, and what is considered the practical limiting voltage for large alternators?

A. The formation of ozone due to corona effect bears indeed on this limit, and too small wires cannot be used unless grouped in a coil. As a rule the main winding is grounded in such a coil and, therefore, there should be no difficulty. The leads might however have to be reinforced. The minimum size of conductor can be found in Mr. Berg's paper in the General Electric Review for February, p. 68.

The General Electric Co. has built an 18,000 volt alternator directly connected to a slow speed engine, and there seems to be good reasons to expect that machines especially of the turbo type, will in the future be built for even higher voltages.

From our present experience it would look as if 25,000 volts might be the limit for quite some time to come. E.J.B.

Questions Asked at Chicago Agents Meeting

(Q) Can 60 cycle lighting transformers be operated at 25 cycles?

(A) If 60 cycle transformers are operated at 25 cycles, their core losses would become so high as to cause dangerous heating of the transformers, and exciting current would probably be increased sufficiently to blow the primary fuses. Such operation is not permissible. M.O.T.

* * *

(Q) What are the relative advantages of a ground shield, and grounded transformer secondaries?

(A) The ground shield has never met with any great favor in American practices, and has in this country, been superseded almost entirely by the grounded secondary. A ground shield increases the cost of a transformer, and is effective only in the event of an internal cross between the primary and secondary windings of a transformer. Practically the major portion of accidents due to a cross between the primary and secondary systems, result from a cross between the high and low voltage systems outside of the transformer. The grounded secondary protects against either internal or an external cross and is to-day very favorably considered by many of the central station managers. M.O.T.

(Q) What is the unbalancing of three-wire Type H transformers when only one side of the three-wire system is loaded?

(A) The unbalancing of the three-wire system under the above conditions, would simply be the regulation drop of the transformer, that is, if we had a 10 kw. transformer in which the regulation drop was 2 per cent, 5 kw. could be taken from one side without exceeding the regulation drop of 2 per cent mentioned. The actual voltage drop, however, would be one-half the total voltage drop obtained when the entire winding was loaded. In other words, with a 115/230 volt secondary, the regulation drop across the entire winding would be 2 per cent. of 230 volts, namely 4.6 volts, while the regulation drop across one-half the windings under the conditions mentioned would be 2 per cent of 115 volts or 2.3 volts. M.O.T.

* * *

(Q) Can three-phase transformers be operated single-phase? If so, what load can be taken from the windings?

(A) A three-phase transformer can be operated single-phase and deliver without injurious heating approximately 85 per cent of the three-phase capacity. M.O.T.

* * *

(Q) What is the objection to running an induction motor on a system having unbalanced voltages?

(A) The unbalanced voltages will cause unequal distribution of current in the motor and excess local heating, thus if the difference in voltage is 10 per cent, there will be a portion of the winding having a rise in temperature 40 per cent greater than would occur for the same load with balanced voltages, and for 15 per cent unbalancing, the maximum local temperature rise would be 75 per cent greater than for the same load on balanced voltage.

W.I.S.

SALES NOTES

The Arlington Mills of Lawrence, Mass., have placed an order with the General Electric Company for a second 2000 kw., 40 cycle turbo-alternator. The first unit was installed and started last fall, and has only been in operation a short time, but has been so satisfactory that they feel warranted in immediately placing an order for a second machine. The generator of this unit is wound for 600 volts and is to be used principally for the distribution of power through their large mills.

A peculiar feature in this installation is the arrangement of the turbines which permits the steam to be taken from the second stage under five pounds pressure to be used in the Dye House, and these are the conditions under which the machines will generally be operated. Both units are of the condenser base type.

* * *

Amesbury, Mass., has long enjoyed a world wide reputation for the manufacture of horse drawn vehicles. It now promises to become equally well known in the manufacture of electric vehicles. Of its various manufacturers probably no firm is better known than S. R. Bailey & Co., whose famous "Bailey Runabout" stands pre-eminently at the front of light weight horse-drawn vehicles. This firm is now placing on the market a line of electric automobiles constructed on original lines and embodying the art and skill which their product has always represented. General Electric automobile motors with continuous torque controllers will be used throughout their equipment. Orders for the first sixty complete outfits have just been placed with the General Electric Company. The 1907 samples already shown by the Bailey Company are attracting the most interested attention and it is anticipated that their exhibit at the Boston Automobile Show will still further stimulate interest in this new product of an old and most favorably known firm.

* * *

The Utah Copper Company, Garfield, Utah, is using one of our L. M. 103 4-1/2 Ton Locomotives with gathering reel in connection with the construction of their new Ore Concentrating Mill, the capacity of which will be 6000 tons for 24 hours and this will shortly be increased to 12000 tons.

In construction, a large quantity of machinery and steel has to be handled after it is removed from the cars. To facilitate this it is placed on small flat cars hauled by the above locomotive, and with a reel having 600 ft. of cable, a distance of 1000 ft. is covered without the necessity of a trolley, which would interfere with the other work. This locomotive has also been used to considerable extent in the place of a hoist for raising the steel and heavy timbers in building. The Superintendent of Construction of this plant states that this has been the most useful piece of apparatus used in the entire construction of this plant.

* * *

The U. S. Smelting Company, Bingham Junction, Utah, has been furnished with 5—CO., 7 1/2 h.p., 850-500 volt series wound motors, with solenoid brake for operating the hoods of their copper converters. These hoods weigh several tons and were formerly moved with a hydraulic piston. This was expensive to keep up, and, furthermore, required a special hydraulic system. The above motors are coupled to a worm gear which moves these hoods, and by means of a switch operated by a rope and lever, these motors are started and automatically stopped when the hoods have reached a predetermined point.

* * *

The Mammoth Copper Mining Company, Kennett, Cal., which has heretofore almost exclusively used competing apparatus, has recently purchased from the General Electric Company one I-20-300-360-2080 volt, four I-14-225-514-2080 volt and one I-20-750-360-2080 volt induction motors; besides two C.L.-6-110-600 motor generator sets and two L M.-202-B-2 13 ton locomotives.

The locomotives are for surface haulage which will replace the present aerial tramway, the operation of which is somewhat unsatisfactory, owing to the frequent run-aways resulting in shut-downs and expensive repairs.

* * *

An order has been received from the Mexico Tramways Company of Mexico City, for fifteen four-motor GE-87 Equipments with automatic Type M Control. These are the first Type M Multiple Unit Train Control Equipments to be installed in Mexico. These will operate trains, consisting of two motor cars with one trail car placed between them. The Mexico Tramways Co. have also lately purchased ten four-motor GE-70 Railway Motor Equipments with K-6 controllers and auxiliary contactor equipment. This is the first installation of contactor equipments with series parallel controllers in Mexico

* * *

The Mexican National Sugar Refining Company have just ordered from us two 300 kw. three-phase, 60 cycle, 2300 volt generators for coupling to one Samson turbine. Belted exciters will be driven from the generator shafts. These generators will furnish power for operating 60 cycle form K, 220 volt induction motors, aggregating 400 h.p., which are also included in this order. Order has also been placed by this same company through the American Tool and Machine Co. for ten 40 h.p. vertical shaft, 220 volt, 60 cycle induction motors for operating sugar centrifugals. The remaining motors will operate various types of sugar-making machinery, elevators, etc.

This will make one of the most important mill installations in Mexico. The order placed with us includes transmission line and lighting equipment, including arc lamps for outdoor use around the mill, 350 incandescent lamps for interior lighting together with all the wiring.

* * *

The Copper Queens Consolidated Copper Co. has just placed an order with us for three ATB 4-1000-1800-6600 volt, 60 cycle steam turbine units complete. These will be installed at the plant of the Moctezuma Copper Co., Nacozari, Sonora, Mexico. These are the first 1000 kw. turbines to be shipped into Mexico, and this installation will be by far the largest turbine plant in that country. These will also be the first of the new 60 cycle, 1800 r.p.m.-1000 kw. units to be shipped from the factory.

The Dodge Coal Storage Company has received the contract from the Berwind-White Coal Mining Co. for three coal unloading bridges to be installed at their Duluth docks. The Dodge Coal Storage Company has given us the order for the entire electrical equipment of these bridges and in addition we are supplying complete apparatus for transformer sub-station. The power for operating the complete plant is furnished by the Great Northern Power Company at 12000 volts, 25 cycles. The equipment for each of the three bridges will be as follows:

1—ITC 5017, 225 h.p., 470 r.p.m., 440 volt hoist motor;

1—ITC 5015-75 h.p.-470 r.p.m.-440 volt trolley motor.

With each of these motors type M control will be furnished, which will be operated by 2 C-49 foot operated controllers, one of which will be mounted at either end of the bridge to insure control of either motor from two points. There will also be supplied in connection with each bridge one ITC 5015-75 h.p.-470 r.p.m.-440 volt motor for revolving crane and one ITC 5012-27 h.p.-460 r.p.m.-440 volt motor for screening tower. Each of these motors will be operated by standard T controllers. There will also be installed with each bridge, 2-100 h.p. motors running at about 500 r.p.m., operated by T controllers, and operating continuously, driving box car loaders. The step-down transformer station will contain 3-WC 25-500-13200-480-460 volt transformers with 42 1/2 per cent taps in the primary. These motors will be cooled by two small induction motor driven pumps. The station will contain a 35 kw. induction motor generator set for supplying direct current at 250 volts for lighting. The General Electric Co. is supplying one Blue Vermont Marble 7-panel switchboard for controlling the 3-phase bank of transformers, the motor generator set with 6 DC lighting feeder circuits, and 6 induction motor feeder circuits.

* * *

An order has been received from the Bath Iron Works of Bath, Me., for two 35 kw., 125 volt direct current turbo generator sets, together with a complete switchboard and one 18 inch projector for pilot house control. The following quotation is in reply to an inquiry as to where these turbines are to be used:

"The two 35 kw. turbines and other apparatus called for on our order, are to be used for lighting the triple screw turbine steamer Camden, building by this company for the Eastern Steamship Co., to run on the Boston-Bangor route. This steamer is 320 ft. long, 40 ft. beam, 14 ft. depth of hold; designed to work at a 10 ft. draft. She is equipped with 4000 h.p. . . . . turbine machinery designed to run at 17 knots speed. She has a large passenger and freight accommodation, and is intended to be a step in advance with a view of taking care of the Eastern Steamship Co.'s growing business on the Bangor run."

It seems quite fitting that a steamer which is to be propelled by turbine engines should be lighted also by engines of this type.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

Illustrated *
Profusely Illustrated **

The Magnetite Arc Lamp

[Cassier's Magazine, Feb. 1907, p. 304 *]

Brief account by Mr. J. L. R. Haden on General Electric Co.'s "Magnetite arc lamp", including curves showing the distribution of light from a four ampere 320 watt magnetite lamp, and a comparative diagram showing the illumination of two streets equipped respectively with ordinary 480 watt series A.C. carbon arc lamps, and 300 watt series magnetite arc lamps requiring 4 amperes at 75 volt direct current.

Snow Test of New York Central Motor Car Trains

[Railroad Gazette, Feb. 15, 1907]

A brief illustrated account regarding the motor car train equipped with General Electric motor and Sprague General Electric Multiple Unit Control. The article states that the performance of this train, in its first encounter with heavy snow, was quite as satisfactory as that of the Electric locomotive No. 6000 on the test track at Schenectady last winter. This latter was reported in the Railroad Gazette, Feb. 16th, '06.

The Electrical Plant at the Cockle Creek Works of the Sulphite Corporation, New South Wales

[Electrical Engineer, Feb. 15, 1907, p. 222*]

Interesting description of the works of the Sulphite Corporation, Limited, at Cockle Creek operating two 150 h.p. 390-650 rev. per. m., 250 volt General Electric motors for driving large vertical blowing engines. The speed variation of about 35 per cent is being obtained by means of shunt control. There are also installed a number of other motors of various sizes ranging from 65 h.p. down to 0.5 h.p., which are nearly all of General Electric make, as is the switchboard controlling the entire plant.

The Hydro-electric Plant of the Utica Gas and Electric Company

[Electrical Review, Feb. 23, 1907, p. 299*]

The water power of the West Canada Creek is being used near the village of Trenton Falls, N. Y., for developing almost 9000 h.p. in four main units consisting of vertical shaft, 2000 h.p. 360 r.p.m., 2300 volt water wheel driven three-phase alternators; with two 100 h.p. 750 r.p.m., 125 volt water wheel driven vertical shaft exciters.

Current is being stepped up to 23000 volts for transmission to the sub-station at Utica.

The entire electrical equipment is of General Electric make.

The Use of Electricity in Anthracite Mining Advantages of Modern Equipment Compared with Obsolete Methods

[Engineering and Mining Journal, Feb. 2, 1907, p. 241*]

An interesting account by Mr. H. M. Warren, Electrical Engineer of the Delaware, Lackawanna & Western Railroad Co., Scranton, Penn., regarding the advantages of electric power, and giving some brief descriptive data on the equipment at the Woodward Mines, Kingston, Penn. This installation contains three 250/275 volt engine driven General Electric D.C. Generators for the operation of a three wire system furnishing 250 volts to mining locomotives and 500 volts to a pump, hoisting engine and other motors. The total generating capacity of this station is about 1000 h.p. and it often carries an overload of 1500 h.p. The saving in copper due to the use of the three wire system is an item of great importance, as the distance from the power house to the foot of the shaft is about 1200 feet.

Hydro-electric Plant at Kakabeka Falls, Canada

[Electrical World, Jan. 26, 1907, p. 179]

One of the most recent Canadian hydro-electric installations to be placed in service is that of the Kaministiquia Power Company, which is situated at Kakabeka Falls on the Kaministiquia river. The power generated by the Falls is transmitted twenty-five miles to the town of Fort William, where the machine shops of the Canadian Pacific and new Grand Trunk R. R. are located.

The power station equipment includes: Two 5000 kw., 4000 volt, horizontal shaft, water wheel driven, three phase alternators, three more of which are to be added later.

Two 150 kw. 125 volt water turbine driven exciters, and

Two banks of three 1675 kw. 2300-14475/23000 volt single-phase air-blast transformers.

The two high tension transmission lines are protected by guard wires running along the pole tops and along the outer ends of the upper cross arms. The circuits are controlled by means of motor operated oil switches.

The system is connected in star, with grounded neutral, except on the low tension side of the sub-station.

The complete electrical equipment is of Canadian General Electric manufacture.

Maywood Power Station of North Shore Electric Company, Ill.

[Western Electrician, Feb. 16, 1907, p. 141**]

A number of towns and villages around Chicago having an aggregate of approximately 200,000 inhabitants, are being supplied with electric current from four interconnected modern power plants, erected by the North Shore Electric Co., which has absorbed many of the older concerns supplying light and power from 11 different central stations. The Maywood Power Station is located about 15 miles west of Lake Michigan on the Desplaines River, which provides ample facilities for receiving coal and obtaining water for condensing and boiler feed.

The electrical equipment includes:

500 and 1000 kw. (Normal rating) 4000 volt star connected, 60 cycle, General Electric Curtis steam turbine three phase units.

Two 125 volt exciters, one 25 kw. engine driven and one 40 kw. induction motor driven.

Two banks of 75 kw. and 200 kw. 2300 volt—10000/20000 volt transformers;

Type CR feeder regulators, etc.

The extensive switch-board installation includes:

Type F, form K3 hand operated, and form K6 solenoid operated oil switches. Each of the three-phase high tension transmission lines is protected by means of a bank of 20,000 volt lightning arresters and choke coils. There is also installed a 6 panel switch-board for the control of the constant current transformers supplying series A.C. street-arc and the incandescent lamp circuits.

INDEX

A. I. E. E. Branch Notes 118

Applications of Electricity in Paper Mills, by W. L. Merrill 103

Arc Lamps, by A. M. Jackson 100
  Magnetite (abstract) 123

Automobiles, S. R. Bailey & Co. (Sales Note).......... 122

Boats, Bath Iron Works, for Eastern Steamship Co. (Sales Note) 123

Brebner, George A., Obituary 116

Coal Dodge Coal Storage, for Berwind-White Co. (Sales Note) 123

Compensators, Starting, by E. F. Gehrkens............. 95

Education:
  Training of Electrical Engineers, by Prof. F. B. Crocker 89

Generating Plants:
  Kaministiquia Power Co., Hydro-electric Plant of, Kakabeka Falls (abstract)........................ 124
  Maywood Power Station, North Shore Electric Co. (abstract) 124
  Utica Gas and Electric Co., Hydro-electric Plant of (abstract) 123

Mills, Cotton:
  Arlington Mills, Lawrence, Mass. (Sales Note).... 122
  Paper: Applications of Electricity in Paper Mills, by W. L. Merrill 103
  See also "Motor Drive" and "Refineries."

Motor Drive:
  Data on Motor Installation, Krell Piano Co., Cincinnati, Ohio, by L. T. Rainey 108
  Motor Driven Blowers, etc. See "The Electrical Plant at Cockle Creek Works of Sulphite Corporation (abstract) 123
  See also "Mills."

Mines and Mining:
  Electricity Used in Anthracite Mining (abstract).. 123
  Mammoth Copper Mining Co., Kennett, Cal. (Sales Note) 122
  Copper Queens Consolidated Copper Co., Mexico (Sales Note) 122
  U. S. Smelting Co., Bingham Junction, Utah (Sales Note) 122
  Utah Copper Co., Garfield, Utah (Sales Note)...... 122

Notes 116

Paper Mills—See Mills.

Questions 120

Refineries:
  Mexican National Sugar Refining Co. (Sales Note) 122

Socket, Security Snap, by J. G. Dallam.................. 112

Surges and Oscillations, by Charles P. Steinmetz......... 91

Third Rail and Overhead Trolley Construction, Comparison of, as Applied to Electrification of Steam Roads, by C. E. Eveleth 113

Traction:
  Mexico Tramways Co., Mexico City (Sales Note).. 122
  Snow Test of New York Central Motor Train (abstract) 123
  See also "Third Rail and Overhead Trolley Construction" and "Generating Plants."

AUTHORS' INDEX

Crocker, Prof. B. F. Training of Electrical Engineers.. 89

Dallam, J. G. Security Snap Socket..................... 112

Eveleth, C. E. Comparison of Third Rail and Overhead Trolley Construction as Applied to Electrification of Steam Roads 113

Jackson, A. M. Arc Lamps 100

Merrill, W. L. Applications of Electricity in Paper Mills 103

Rainey, L. T. Data on Motor Installation, Krell Piano Co., Cincinnati, Ohio 108

Steinmetz, Charles P. Surges and Oscillations.......... 91

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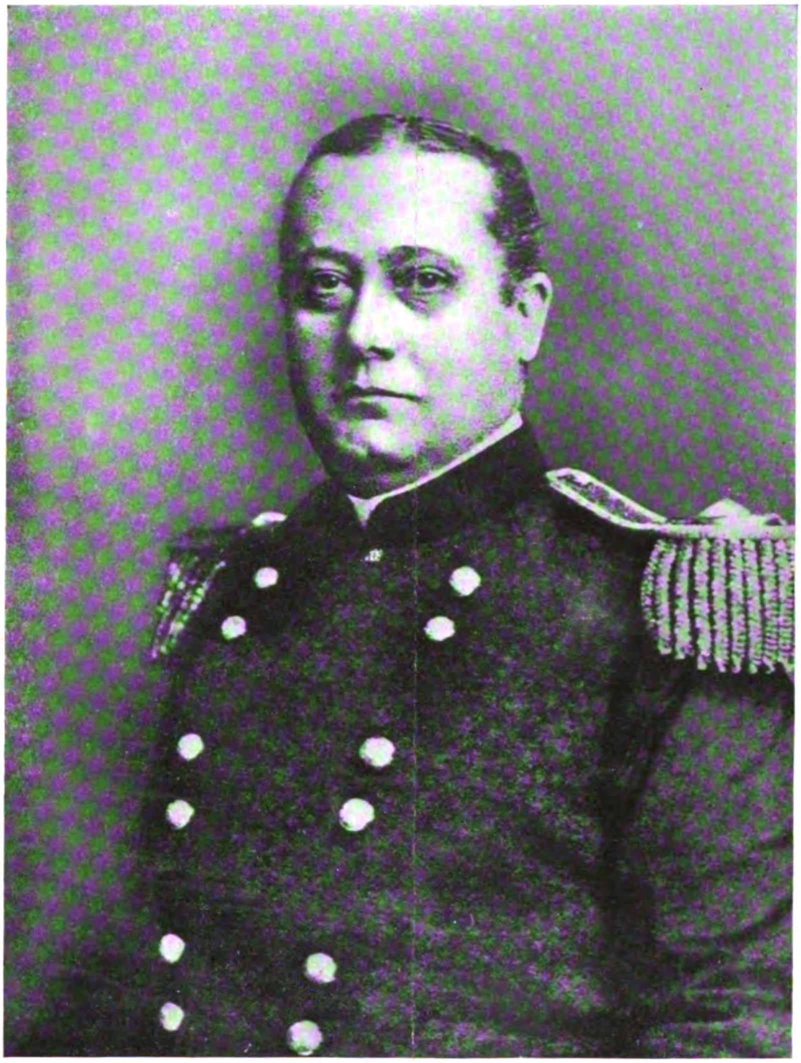

Eugene Griffin
Brig Gen. of Vol.

GEN. EUGENE GRIFFIN

Eugene Griffin was born in Ellsworth, Me., October 13, 1855, and was educated in the public schools of that place until he entered the United States Military Academy at West Point, from which institution he was graduated in 1875 with high honors, standing third in the class of that year.

Immediately following his graduation, he was appointed Second Lieutenant of Engineers in the United States Army, and was assigned to duty at the Engineering School of Application at Willet's Point, where he remained until 1877. During the years 1878-80 he was in charge of a party of engineers in the United States Geographical Survey in Colorado, New Mexico, Arizona and Texas. He was promoted to First Lieutenant in 1880 and was in charge of surveys of Governor's, Ellis, and Bedloe's Islands in New York harbor.

From 1883 to 1885, he was Assistant Professor of Civil and Military Engineering and the Art of War at West Point. In 1885 and 1886 he was aide-de-camp to Gen. Winfield Scott Hancock. From 1886 to 1888 he was Assistant Engineer Commissioner of the District of Columbia, having charge of all matters pertaining to electric lighting, telegraph and telephone companies in the City of Washington.

In 1887 he was promoted to Captain in the Corps of Engineers.

It was while occupying the position as Assistant District Engineer of Washington that the attention of the officials of the Thomson-Houston Electric Company of Boston was attracted to him, through a report which he had made on the possibilities of electric railways and electric lighting in the City of Washington. Obtaining a year's leave of absence from the Military service, he entered the employ of the Thomson-Houston Company early in the year 1888 to organize and manage its Railway Department, then just being formed. Although the application of electricity for the propulsion of street cars was in its infancy, he had unbounded confidence in its future development, and foresaw even then, the almost perfect state to which it has now been brought.

The first electric railway equipped by the Thomson-Houston Electric Company was started at Revere Beach, near Boston, on the 4th of July, 1888, under Captain Griffin's energetic direction and other installations at Scranton, Pa., Washington, D. C., Des Moines, Iowa, Omaha, Neb., and at Boston, Plymouth and Lynn, Mass., followed in rapid succession.

In 1892 the General Electric Company was organized and absorbed the Thomson-Houston and Edison General Electric Companies. Captain Griffin was elected Director and First Vice President of the new company, which official positions he held at the time of his death.

In the reorganization of the Thomson-Houston and Edison General Electric Companies, which were formerly severe competitors, Captain Griffin displayed great diplomacy, business ability and skill as an organizer, in shaping a new and harmonious organization and bringing about important internal changes. The marvelous growth of the General Electric Company, and its varied engineering and commercial work, are a conspicuous monument to his memory.

Upon the declaration of war with Spain in 1898 he offered his services to his country, and in May of that year was commissioned by President McKinley to organize the First Regiment of Volunteer Engineers. As Colonel of that Regiment he went into camp at Peekskill in July with 1100 men and officers, and on August 10th sailed from New York and landed at Ponce, Porto Rico, shortly before the termination of our brief war with Spain. He was promoted to the rank of Brigadier General prior to his regiment being mustered out of service, and at the close of war he resumed his active duties with the General Electric Company.

In the later and highly successful years of his business career, despite failing health, his zeal and interest in the affairs of the Company he served, and in personal devotion to his colleagues and subordinates to whom he was deeply attached, never abated, and it can truly be said of him that he died at his post of duty, still working with all his remaining energy for the advancement of the interests of his Company.

In all his relations, business, personal, or social, General Griffin was the embodiment of honor and courtesy. He was endowed with an unusual range of capabilities and accomplishments, which gave him in every sphere of life a marked personality and an especial beneficent and helpful influence.

He maintained up to the last the liveliest interest in West Point, and enjoyed a deserved popularity among his old comrades and later pupils, and was a frequent visitor at the Military School which he loved so well. His burial at West Point on Saturday, April 13th, with high military honors and amidst the scenes to which he was so deeply attached, was in harmony with his personality and his constant loyalty to American soldiers and military traditions.

MULTIPLE UNIT CONTROL FOR D. C. MOTORS

Part I

By G. H. Hill*

The hand-operated platform controller for the smaller sizes of electric street cars has for a number of years been built in the same general form. A cylinder directly attached to the handle; segmental contacts thereon, engaging stationary fingers which cut out starting resistance and commutate the motor connections from series to parallel; and provision for a magnetic blowout of the arcs, constitute the principal features of the accepted form of this apparatus.

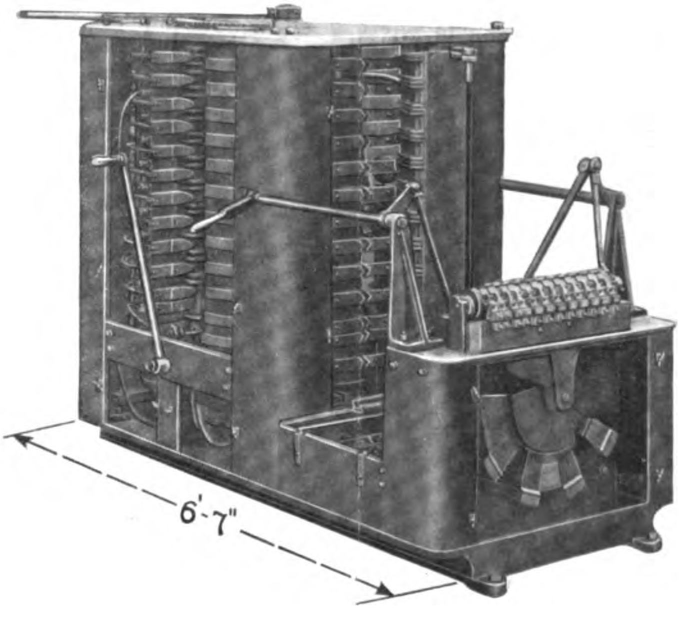

Fig. 1. Cylinder Hand Controller for B. & O. Locomotive

Minor modifications and improvements are incorporated occasionally, but the main features are standardized.

This design, however, was not reached

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*Read before the New England Railroad Club by any obvious and direct path, but involved a long succession of experiments, tests and failures. Many brilliant schemes —products of energy and ingenuity—covering nearly every imaginable construction the period of development.

The enormous growth of street railways utilized a large number of the final "K" form of controller, and with the gradual increase in size and power of motor equipments, the controller was made in larger sizes and increased capacity. Probably the largest hand controller ever attempted for railway motors was the one for the 800-HP B. & O. locomotives built in 1896. found their way to the scrap pile during

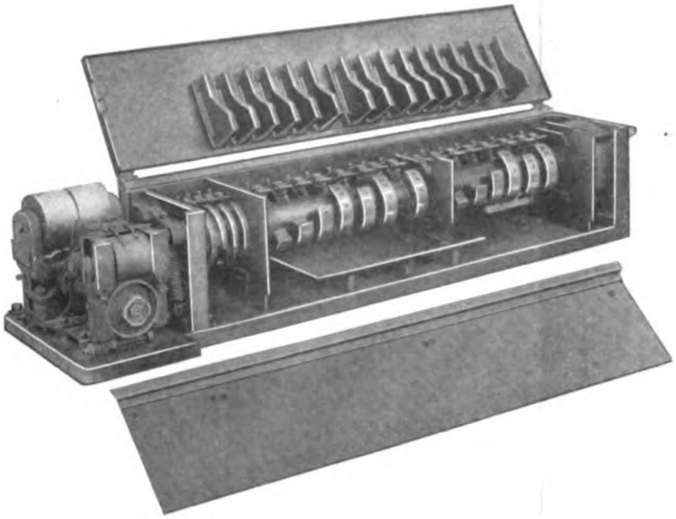


Fig. 2. Sprague Type Cylinder Multiple Unit Controller

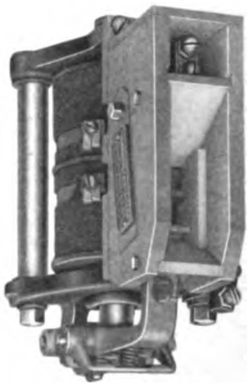


Fig. 3. General Electric Contactor

The size of this controller, shown in Fig. 1, is so great that it occupies much valuable room in the cab and is rather difficult to operate.

In addition to the size and weight, the control of such large motor capacities on a single cylinder-type controller is attended with much difficulty, and it was evident at that time that the progress of controller construction was limited in the matter of motor capacities unless some more efficient form of controller was devised.

About this period there was brought forward a new plan for controlling train units of large aggregate motor capacity, now well known as the multiple unit system. The idea was evolved primarily to secure increased traction and rapid acceleration without excessive localized weights, thereby permitting the existing elevated railways to increase their passenger-carrying capacity, then taxed to their limit with steam locomotives.

Not until the historical installation of this new system on the Chicago Southside Elevated Railway, was the value of the idea fully appreciated. This demonstration, however, put at rest the doubts frequently expressed as to the practicability of the multiple unit idea on account of its complexity, and furnished an impetus to electric traction unparalleled in its history.

The first application of the multiple unit system naturally utilized the accepted cylinder type of controller, the cylinder being driven by a small motor instead of by hand, and the motors controlled synchronously and simultaneously from a single point through a secondary system of train wires and relays. The segregation of motor units and their controllers, although of large aggregate capacity, permitted the use of substantially standard control construction on individual cars. In Fig. 2 is shown one of the Sprague type of cylinder controllers with pilot motor drive.

From the first application, involving two 50-HP motors per car and per controller, the requirements soon reached 500 and 600 HP per car, and the limitations of the cylinder form of controller again came into evidence. This condition gave rise to the separate contact system, or contactor system of control, which is now well known to all electric railroad engineers.

Essentially the contactor system constitutes simply a segregation of the controller parts. Each contactor, Fig. 3, performs the function of a controller finger and its accompanying segment. The advantages of the contactor over the cylinder form, aside from providing a flexible system readily permitting a variety of contact groupings and arrangements with standard parts, arise from the ability to effectually isolate the different motor circuits and provide a powerful and directly applied blowout device to each current arc.

The success of this new form was immediate and unqualified, and its development most rapid and extensive. It removed the most serious obstacles to the progress of heavy electric traction, and not only furnishes the means for controlling the largest motor units that can be crowded into the limits of the standard-gauge track, but is successfully used for a great variety of other applications with

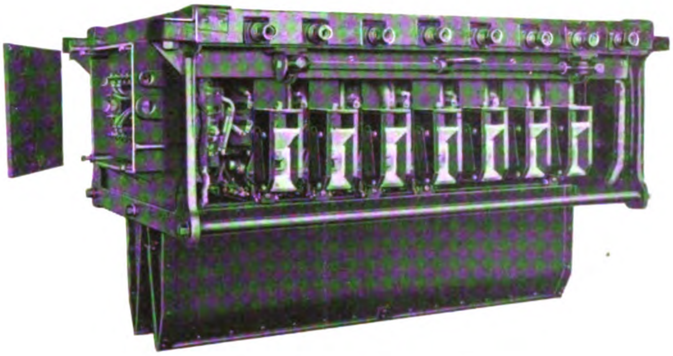


Fig. 4. **Sprague General Electric Contactor Control**

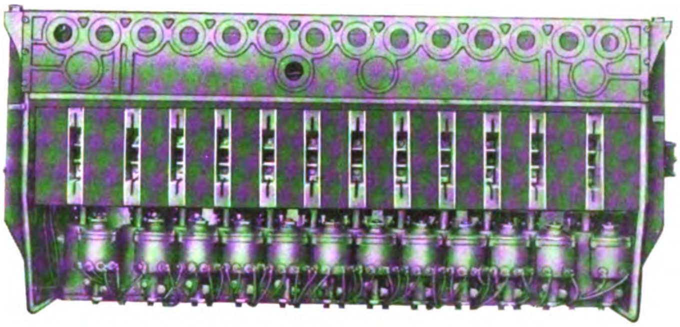
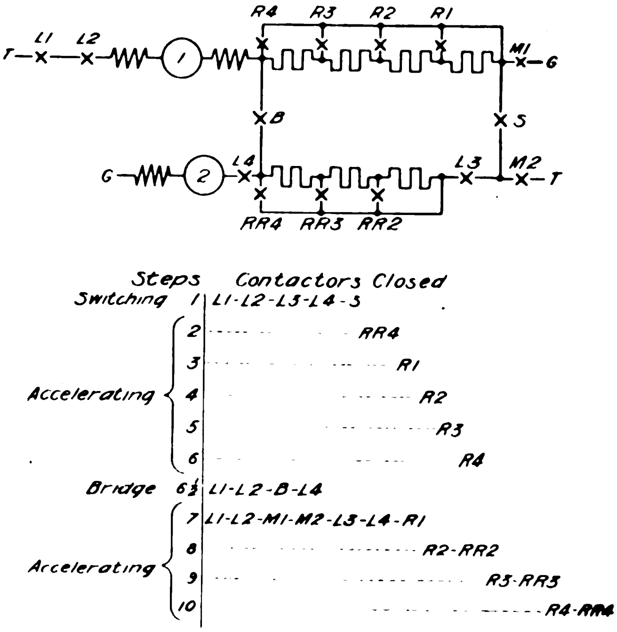


Fig. 5. **Westinghouse Contactor Control**

motors ranging from a very low horse-power capacity to 1,500 horse-power and over, in such difficult and intermittent service as rolling mills, mine hoists and the like.

At the present time there are two general types of multiple unit control apparatus. Of these types there are several distinct forms adapted to the different requirements and conditions. The general types are substantially alike in their essential features, but differ in the means employed for operating the contactor units.



	Steps	Contactors Closed
Switching	1	L1-L2-L3-L4-5
Accelerating	2	RR4
	3	R1
	4	R2
	5	R3
	6	R4
Bridge	6½	L1-L2-B-L4
Accelerating	7	L1-L2-M1-M2-L3-L4-R1
	8	R2-RR2
	9	R3-RR3
	10	R4-RR4

Fig. 6. Motor Circuits of Sprague General Electric Control

In Fig. 4 is shown a Sprague General Electric, and in Fig. 5 a Westinghouse contactor control.

The Sprague General Electric system provides each contact with an electro-magnet to close it, and a spring with gravity to open it. These magnet coils are connected to the train wires, which in turn are connected with master controllers, receiving the current for energizing them direct from the trolley or third-rail shoe.

The Westinghouse system provides each contact with a piston and air cylinder for closing, and a spring and gravity for opening. The air is derived from a motor compressor and admitted and released from the cylinders by electro-magnetic valves. These magnet coils are connected to the train wires, which connect to master controllers and receive energy from a storage battery which is charged from the trolley or third-rail shoe.

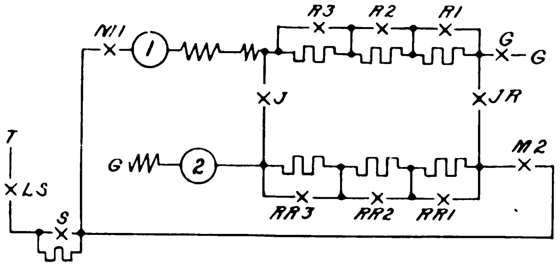
The essential difference between the two systems is the interposition in the one case of the air pistons and valves. The contactor coils in the one system correspond to the electro-magnet valve coils in the other as to function and circuit connections. In the General Electric the various contactor coils are connected in series arrangement, this being most convenient when using the normal trolley voltage for energizing them.

A low-voltage storage battery being used with the Westinghouse system, the coils are connected in parallel. Aside from this, the connections are practically the same.

In Figure 6 are shown the motor circuits of a representative form of the Sprague General Electric system in a simple diagrammatic form, and in Figure 7 those of a representative Westinghouse form.

In both of these diagrams, and in those that follow, the contacts of the switches or contactors are represented by crosses with reference letters. The connection arrangement and successive circuits at each controller step may readily be traced by means of the key accompanying each diagram.

Both arrangements provide a "bridge" or closed circuit transfer from the series to the parallel connection of motors. For this purpose, as well as to effect a most efficient use of rheostats, a separate set of resistances for each motor circuit is provided, and these sets of resistances are changed from series to parallel connection along with the motors. The current carried by any resistance section is the same in parallel as in series, and the total amount of resistance, excepting one step, is in use both in series and in parallel. A less number of rheostats may thus be used for a given motor capacity than would be necessary if a single set of resistances were used for both motors, since in the latter case only a portion of the resistance could be in circuit in the parallel connection, and the current capacity of this portion would necessarily have to be for twice the single-motor current.



	Steps	Contactors Closed
Switching	1	LS-M1-JR
Accelerating	2	S
	3	RR1-R1
	4	RR2-R2
	5	RR3-R3
Bridge	5½	LS-M1-S-J
Accelerating	6	LS-M1-S-G-M2
	7	RR1-R1
	8	RR2-R2
	9	RR3-R3

Fig. 7. Motor Circuits of Westinghouse Control

The contactors B and J, in Figures 6 and 7, respectively perform the function of the bridge transfer.

Immediately following the series connection with the resistance all short-circuited, the bridge contactors are closed and the resistance and series contactors opened —steps 6½ and 5½ respectively. The motors are thus in the series relation, and the circuit is independent of the resistance contactors. By next closing the parallel contacts M1 and M2, Figure 6, or M and G Figure 7, the motors are immediately in parallel. The bridge circuit is now simply an equalizer connection, and with properly proportioned resistance, carries no current. The bridge contactor is next opened and the resistance in each motor circuit cut out step by step.

In both arrangements the first series connection, with all resistance in circuit, forms a "switching" step of lower current value than is used for acceleration. This permits a slow movement of the car when coupling or switching.

In Figure 6, on the second step, which is the first accelerating step, all of the No. 2 motor resistance is cut out of circuit, so that the series acceleration steps are produced by cutting out the No. 1 motor resistance alone.

In Figure 7 a separate resistance, S, is provided for the switching step, and the accelerating resistances are cut out in series in the same way as in parallel.

Figure 6 provides five accelerating steps in series and four in parallel, while Figure 7 has four in series and four in parallel. This point will be referred to later.

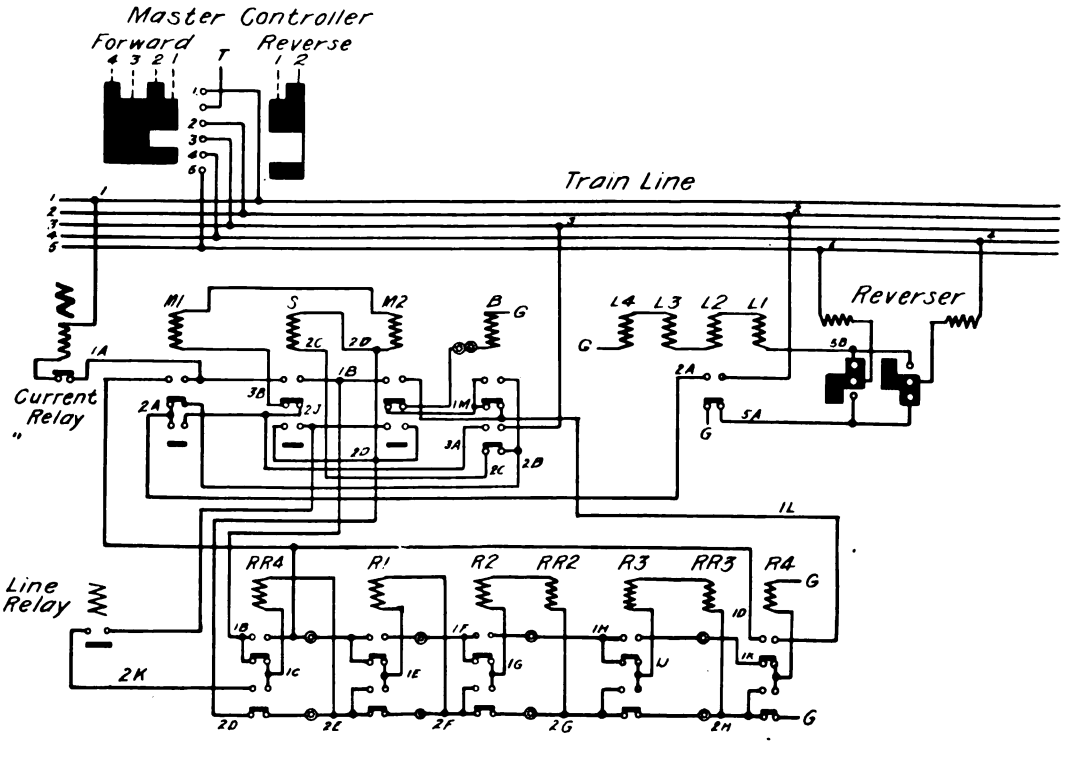


Fig. 8. Control Circuits of Sprague General Electric Control

Figures 8 and 9 show the control circuits corresponding to the motor circuits in Figures 6 and 7, and are also given in as simple diagrammatic form as possible. All of the control connections are included excepting only such details, unessential for present purposes, as cutouts, fuses, etc. The magnet coils are lettered to correspond to the motor circuit diagrams and are so grouped as to make the connections easily traced. The interlocks, which are attached to the movable portion of the contactors in each case, are placed beneath the corresponding coils. When the contactor is closed, the short heavy lines representing the movable portion are considered to move from the lower contacts, as shown, to the upper contacts.

For further convenience in tracing the circuits, the wires are lettered in approximately consecutive order, and below is given a key to the successive circuits.

In Figure 8, consider the master controller on step 1 forward. Current flows from T out wire 4 to reverser coil, wire 5A to ground, G. The reverser throws over and connects wire 4 by wire 5B, through coils L1, L2, L3 and L4 to ground, G. Current then flows through wires 2, 2A, 2B and 2C to coil S and wires 2D, 2E, 2F, 2G and 2H to G. The small double circles are resistances, each approximately equal to the resistance of a contactor coil.

The motors are now in series, with all resistance in circuit. The line relay coil being connected across the motors, is now closed. When the master controller is moved to position 2, current flows through wire 1—current relay—wires 1A, 1B, 1C, coil RR4 to 2E, etc., to G. The relay and contactor RR4 close at the same time. As RR4 closes, the contact between 2K and 1C wires closes before the contact between 2D and 2E opens, and also before the relay contact is opened. The circuit through coil S now passes from wire 2D through 2J, 2K and 1C, coil RR4, 2E, etc., to G.

The heavy coil of the relay is in the motor circuit, and the increased motor current produced by closing RR4 is sufficient to hold the relay, (which has been lifted by the No. 1 wire circuit) and keep its contacts open. When the motor current is sufficiently reduced as the motors increase in speed, the relay drops and closes its contacts. Current now flows through wires 1A, 1B, 1D, 1E, coil R1, 2F, etc., to G. R1 contactor is closed and its coil shifted into the circuit from 2E, in series with S and RR4, and the relay action is repeated. On the next two steps, coils R2, RR2, R3 and RR3 are energized in the same manner. When R4 is closed on the last step, current flows through wires 1B, 1D, 1L, 1M and coil B to G. Contactor B in closing opens the 2C wire, and contactor S and the resistance contactors are opened. B is held closed by current through the 2B and 1M wires.

In position 3 of the master controller, current flows through wires 3, 3A, 3B, coils M1 and M2, wires 2D, 2E, etc., to G. M2 in closing opens the circuit of B, and M1 closes circuit from 2A to 3B, thus holding M1 and M2 closed.

The motors are now in parallel connection.

In the fourth position of the master controller, current flows through wire 1 and the current relay and energizes the resistance contactors in the same manner as in series, but in a different order. Current flows through 1A, 1D and 1E, coil R1, wire 2F, etc., to G, thus closing R1 first in the series. After R1, contactors R2, RR2, R3, RR3 and R4 are closed in consecutive order. When R4 is closed, current flows from wire 1D through 1L, 1B and 1C, coil RR4, 2E, 1E, coil R1, etc., to G. RR4 is thus closed last in the series.

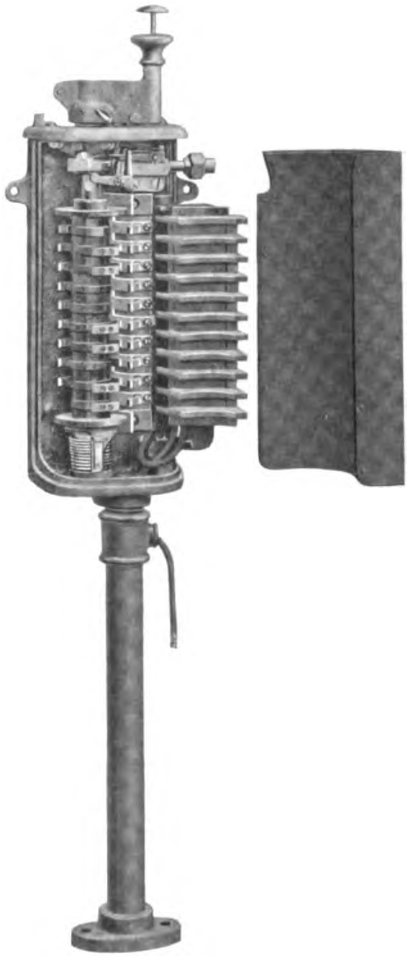


Fig. 10. Master Controller for General Electric Control

In the running positions—2 and 4—there are but two control circuits, one through the reverser and L coils in series, and the other through the S or M, and the R coils in series.

In Figure 10 is shown the master controller for this automatic control.

Considering now Figure 9 with the master controller in position 1, forward; current flows from B+, through wire 2, 2R reverser coil to B–. The reverser throws over and wire 2 is connected through 1A coil M1 to B–. At the same time current flows through wire 6, through the upper coil of LS and overload trips to B–. Current then flows through wires 2, 1A, 1B, 1C, coil JR, to B–, through the line relay, which is energized from the motor circuit when LS is closed.

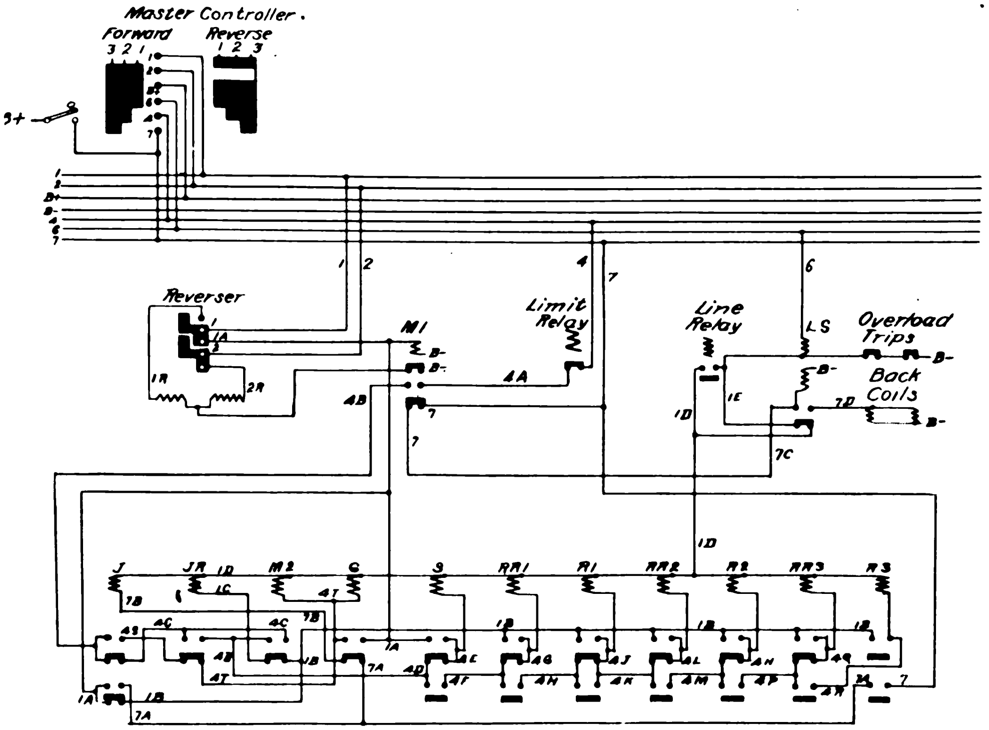

Master Controller.
Forward
3 2 1
Reverse
1 2 3
1
2
B+
6
4
7
B+
1
2
B+
B-
4
6
7
1
2
4
7
6
Reverser
1
1A
2
1R
2R
M1
B-
B-
4A
4B
7
7
Limit Relay
Line Relay
LS
Overload Trips
B-
B-
Back Coils
B-
1E
1D
7D
7C
1D
J
JR
1D
M2
G
S
RR1
R1
RR2
R2
RR3
R3
7B
1C
4T
7B
4S
4C
4C
4B
4T
1B
1A
7A
4D
4E
4F
1B
4G
4H
4J
4K
4L
4M
1B
4N
4P
1B
4Q
4R
7
1A
1B
7A

Fig. 9 Control Circuits of Westinghouse Control

The motors are now in series, with all resistance in circuit.

When the master controller is moved to position 2, current flows through wire 4, limit relay 4A, 4B, 4C, 4D, 4E, coil S to B–. Contactor S closes and cuts out the switching resistance. Coil S is held closed by the 1A circuit now connected to 4E. The increase in motor current causes the limit relay coil, which is in the motor circuit, to open its contacts and the circuit of wire 4. When the current is reduced by the speeding up of the motors, current flows through wires 4, 4A, 4C, 4D, 4F, 4G, coil RR1 to B–. RR1 closes and current flows from the 4 circuit through 4F, 4H, 4J, coil R1 to B–.

In the same manner the coils RR2, R2, RR3 and R3 are closed, the relay acting to stop the progression when the motor current rises sufficiently to energize the relay. When R3 has closed and the master controller has been moved to position 3, current flows through wires 7, 7A, 7B, coil J to B-. J, in closing, opens JR and the R contactors.

The motors are now in the bridge connection.

Current now flows through wires 4, 4A, 4B, 4S, 4T, coils M2 and G, to B-. G in closing opens J.

The motors are now in first parallel step.

The R contactors are now closed successively with the action of the limit relay the same as in series.

It will be noted that since each contactor is provided with the necessary interlocks, the resistance steps in No. 1 and No. 2 motor circuit are cut out individually and alternately. In the series acceleration this divides each step into two half-steps, and in parallel causes the motors to be advanced unevenly, No. 2 being ahead of No. 1 part of the time, and hence taking more than half of the load.

Both of these controls, as explained, are automatic in action, i. e., the succession of accelerating steps, while dependent upon the movement of the master controller to start the advance or check it, does not follow such movement immediately but is governed by the motor current, which passes through the current relays. The principal advantages of such automatic control of acceleration are to produce uniform and comfortable acceleration, with a constant average current input, and as a corollary, the maximum acceleration possible for a given weight on driving-wheels.

To accomplish this, not only must the contactors be made to operate in a definite succession, as shown by the diagrams, but the current during acceleration must be controlled within definite limits, and the proper determination of resistance values is very essential. The proportional resistance values, the number of steps, and the maximum and minimum current values at each step, must bear definite relations in any case, to secure uniformly definite and satisfactory results under variable conditions of grade and load. Unless such definite relations exist, the automatic feature becomes of a hit-and-miss quality, satisfactory only under favorable conditions.

To be continued

SALESMANSHIP.

By F. F. BARBOUR*

The essence of salesmanship is diplomacy. The salesman is the channel between the manufacturer and the purchaser; and for the best results this channel must be broad, reliable, well known, and attractive. Often the purchaser feels that he must be on guard continually against the salesman lest he be taken advantage of; this feeling should be overcome, as only when purchaser and seller stand on the common ground of confidence in each other can satisfactory results be obtained. The salesman must also aim to be adaptable to the circumstances as he finds them. He should not be mushy, giving way to every whim of his customer, but flexible so as not to irritate, endeavoring at all times to so direct and influence the situation that he can meet it with standard products. To do this he must familiarize himself with the history of the purchaser, his character, methods, prejudices, associates, capital. The first three because they tell how to approach and what to avoid; the fourth, because they can often help by a timely word to establish his confidence; the last because he must eventually pay for what he buys, and should be able to do so easily and promptly. If he cannot, you may not want his business at all. Thorough knowledge on these points in advance often saves much time and labor later on. Again, he must know the work already done, and that to be done in the present and in the future. His plans and actions must cover not merely the present order, but others to follow. He should endeavor to so handle the first negotiation that the customer has confidence in his knowledge and his goods, and when the subsequent negotiations arise he is in good standing, and half his battle is won.

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*Read before the Local Branch A. I. E. E.

With these initial qualifications, the first task of the salesman is to know thoroughly the material he is to sell. It must be sold largely from his head and his heart, and not from his catalogue. He must believe it to be the best in the world. This belief can only come from an absolute knowledge of his goods, how they are made and the material thereof. Knowing these things, he can so explain them to the buyer that he, too, is convinced, and the rest is comparatively easy. If by any misfortune, you must offer an inferior article (no man in the General Electric Company has often to do that), be honest about it, sell it for what it is, and for a price commensurate with its quality, and then no criticism can be made.

The second qualification is confidence that you will secure the business—"Faint heart never won fair lady—" and if one goes into a fight doubtful, his battle is half lost.

In approaching a customer it should be the endeavor to find out what he wants to do and how he wants to do it. Fundamentally his problem is to make money for his stockholders. The method may lie through the apparatus the salesman is offering. The detail of the method he may know; if he does he will tell, and then the start is easy. If he is uncertain, then he must be educated as to the latest and best method. Familiarity with past methods, their success or failure will greatly assist in formulating plans for the future work. Hence, the need for full knowledge of these facts on the part of the salesman.

In finding out what is to be done, you probably learn how the customer expects to do it, and he may think he knows best. You may see that his method is obsolete or faulty however, and if so, do not tell him so bluntly—break it easily by showing the advantage of a different way.

In doing this comes the hardest problem we have today,—namely, to meet fully the majority of the problems with standard apparatus, such as is turned out by the hundred or the thousand. Often it seems that it cannot be done; sometimes it cannot, but in eighty-five per cent of the cases, standard apparatus will do the work as well or better than special apparatus.

In this connection the salesman should keep fully posted on factory plans and methods, so that he may recommend in advance the proper thing. Often three-quarters of the selling work is done before the question of price is raised, and if well done enables him to get the right price easily.

Here may a hint be dropped to the manufacturer. The man on the ground, whether he be purchaser or salesman, must be assumed to know best what is needed —if possible give him what he asks for, and if you think something else will do the work better, still give him what he asks for, and offer what you think is better as an alternative—give with it the reason why it is better, and if local conditions are as you think he will receive the recommendation gladly; if not, he will still have what he asked for.

The ideal salesman is in constant contact with various classes of men, beside the final buyers:

First, the Consulting Engineers, who draw up specifications. It should be his duty in part to keep these engineers informed as to the latest types of apparatus —the new things in the business. In no other way can they learn them promptly, they appreciate such attention.

Second, the Operating Engineers in the Central Stations: These are always interested in new appliances—and often want information on the apparatus they are already running. They can often tell us of defects to be corrected, or improvements to be made in our apparatus, or things to be avoided in that of other manufacturers.

Then, too, suggestions made to them often reach the Managers in a far more effective way than when made direct by the salesman.

Third,—the Superintendents. On them rests the burden of operating economy. Any new method or apparatus which accomplishes economical results interests them, and eventually they will adopt it in part or in whole. When they do they will favor the man who first told them about it.

Fourth,—the Managers. On them rests the problem of satisfying both the public, their customer, and the Directors and Stockholders, their employers. Any device which consumes current and makes trade interests them. New uses, such as heating, cooking, etc., open up sources of revenue, and they are glad to advertise them. This gives salesmen a chance to sell new goods when it would be impossible without the recommendation of the Manager.

Competition

This is a necessary adjunct to a salesman's existence; without it his goods would sell themselves. It is stimulating, inspiring, and forces a man to his best efforts. It is like a tonic and keeps him up to standard. In meeting it do not fall into the error of running down competitors' apparatus; that is a sign of weakness. Study competitors' product to find its weak and its strong points; bring out the strong points in your own material and, if possible, make especially prominent those points in which you are strong and your competitor weak. To do this you must know competing apparatus as well as your own.

A salesman handling electrical apparatus cannot have too much general information. He should know about steam, hydraulics, finance—all allied to his own line, and in addition as much as may be of literature, politics, commercial law, and in fact anything which will make him a broad, all-around man. He should be able to tell a good story, but let it be clean and worth while.

There come times to every salesman when his problem involves engineering of a high order. At such times the aid of his district engineer, or even of the factory engineer is imperative and should be requested as early as possible in the negotiation. Do not be afraid to use him—you cannot do everything—give your engineer a chance to help you and make the opportunity a large one.

I remember when our good chairman, (Mr. Rushmere) came to California to help us on a large negotiation. The customer wanted information in large blocks, some of it seemingly irrelevant. Our engineer sat there, unruffled, with a slide rule and designed machines while I waited, and almost faster than I could put the figures down. Then we went to the customer and gave him such a mass of information on the design and construction of machines, together with the prices, that he was swamped, and finally gave us the order for about what was originally offered. Without the engineer, and his knowledge and resource, we could never have won.

Again, be a good loser; one cannot get every order he goes after. If a contract is lost, lose it gracefully. Go away with a smile, and leave a good impression on the customer. He likes a "game" man, and next time he will give him another chance and a fair one. Forget the failures, except so far as they teach how to avoid others, and start afresh with new courage for the next order.

No set rules can be laid down by which every man can work. His personality, as well as the customer's, must enter into every deal. Be quick to see the set of the tide—always have something in reserve—and in this way shall success crown your efforts and apparent defeat give way to victory.

THERMAL PROBLEMS OF STATIC TRANSFORMERS.

By W. S. MOODY *

I

Introductory

At the present time, when transformers having capacities running into the thousands of kilowatts are very common, and when sizes equal to the largest alternators are being built with the same degree of accuracy, we almost forget, and perhaps many are not in a position to know, that a few years back, when alternators were built in 1000 kw. sizes, transformers had hardly reached the 25 kw. mark.

This slow progress in the development of the large transformer unit was almost entirely due to the retarded mastery of the thermal problem. The difficulty attending this problem was how to dissipate the heat generated.

The source of the heat is, of course, the losses — iron, copper and eddy — and its effect is, first, carbonization, and second, mechanical displacement due to expansion and contraction of the insulation. The first effect is perhaps the more serious.

Retarded Progress and Reasons

Form Comparison

Two general reasons may be mentioned for the delay in the mastery of the heat problem. First, the effect of earlier experience and custom; and second, the form which the transformer assumes. Being naturally compact and following mathematical laws, the volume, and hence the capacity and heat generated increase more rapidly than the surface for dissipating the heat.

The generator was, in general, designed without any artificial means of cooling, other than that produced by its own rotation. Although the general characteristics of the alternator (with the exception of efficiency) are approximately the same as those of the transformer, the form it assumes is widely different, being principally dependent upon the frequency of its current, a condition fixed by the number of its poles and speed; naturally producing a machine whose working material is spread over a large area when compared with the transformer. In general, every point of the working material of the alternator is also close to points of heat dissipation. These facts, together with the artificial cooling which is self-produced, naturally eliminated the necessity for solving any serious thermal problems in alternators.

Early engineers were largely governed by previous experience, methods and practice, (as are engineers of the present time for that matter) and since no provision was made for artificial heat dissipation in the alternator, the transformer designer did not readily take to artificial cooling, and the customer also was slow in accepting apparatus which had to be artificially cooled.

Early Assumption of the Thermal Problem

The bounding area of the transformer was for a long time considered the only available cooling surface, and internal ducts as so much waste space. As late as 1890, one of our own engineers wrote an article in which he attempted to prove that the 15 kw. transformer would be cheaper per kw. than one of twice the size, due to the lower current and magnetic densities which he thought would have to be used in the large size in order to keep within heating limits. This proof was roughly as follows:—

If the same densities in copper and iron, and the same total flux were maintained, the increase in actual weight, volume and

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* Read before Local Branch of A. I. E. E.

loss of a 30 kw. would be approximately as the square root of 3, while the radiating surface would be a little less than the square root of 2; so that in order to reach a point where the cooling surface per watt loss was the same, the weight of material would have to be increased something like 4 times, reducing the current and magnetic densities to approximately ½ of those of the 15 kw. transformer, while if built in two separate units, only twice the material would be necessary.

While this line of reasoning might today be considered as showing a serious lack of knowledge on the part of the engineers, you will be surprised to know that the following quotation appeared in a standard text book written by a well known authority and published as late as 1896.

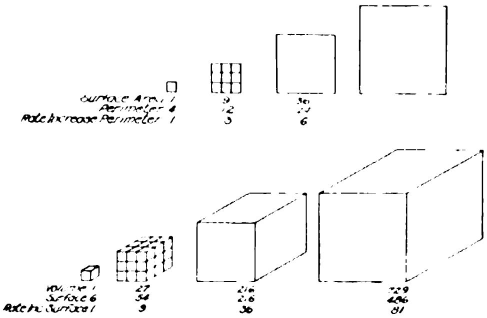


Fig. 1. Relation Between Surface and Perimeter; Volume and Surface

"Machinery and mechanical apparatus generally become, as a rule, more efficient when made on a larger scale, and judging by this fact we should expect *large* transformers to have an advantage over small, both as regards the efficiency and also the amount of material required per kilowatt output. Within certain limits this is indeed the case. A 10 kw. transformer weighs less than 10 transformers of 1 kw. each, and its efficiency is also higher. But if we compare a 100 kw. and a 10 kw. transformer, the advantage of the larger apparatus, especially as regards weight, is not so great and may under certain conditions vanish altogether, the reason being that the larger apparatus has relatively to its weight or bulk a smaller cooling surface. If the power lost per unit of cooling surface and therefore the temperature is to be kept within the original limits, the magnetic stress in the iron and the electric stress in the copper must be less than with the smaller apparatus; hence, the advantage generally incident to mere size may, in part or entirely be lost, because of insufficient cooling surface. As long as the smaller of the two transformers is of such a size that the cooling surface is largely in excess of what is required, then the large transformer may be worked at a higher and yet safe temperature and full advantage be taken of the increased size; but if the small transformer is itself already near the limit of output as determined by temperature, then this limit must also determine the output of the large transformer, and the better utilization as regards the material is marred by the less favorable conditions as regards cooling surface."

Different Treatment of Large and Small Transformers

Since the transformer was evolved from Faraday's induction coil, and as early transformers were of small capacity, they were, as a natural consequence, designed in very compact form. The cooling surface was ample to dissipate the heat and the distance from the innermost points of heat generation was small, so that the designer was not compelled to make any provision' for cooling. These conditions hold for small capacity transformers of the present day, except that it is possible to build larger self-cooled units, on account of the better grade of copper and iron which we may now obtain.

Comparatively speaking, the capacity of transformers which may be designed without considering the thermal problem is small, being less than 5 kw. On sizes larger than this the cooling feature must be considered. The larger transformers therefore require absolutely different treatment. The coils and core must be arranged with ducts, so that all parts are kept at low working temperatures. The insulation must be applied in such a manner that it shall not be injured by buckling or stretching under expansion and contraction of working parts, caused by the varying conditions of service.

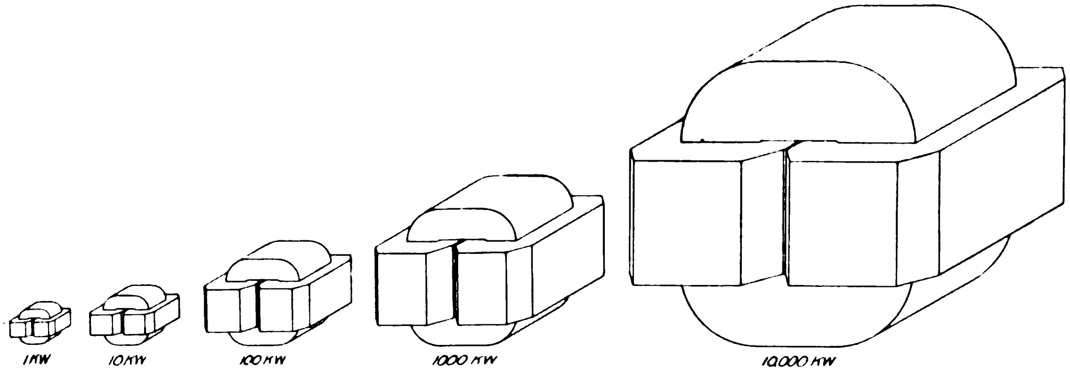


Fig. 2. Comparative Outlines 1 to 10000 Kw. 60 Cycle 2000 Volt Transformers. Without Internal Ventilation.

Kw.	1	10	100	1000	10000
Weight, lbs.	60	310	1520	10500	46000
Dimensions,	8x12x6	12x16x11	21x25x16	33x39x27	55x61x43

The casing of the transformer, if it is of the oil cooled type, must be designed to give the best cooling in the least possible space, and if water cooled, air blast or forced oil, the same careful attention must be paid to cooling. In fact, there is scarcely a single step in transformer design which does not carry with it the thermal consideration, and these considerations are made still more difficult to the designers by electrical and commercial limitations. Almost perfect operating characteristics and high efficiency must in general be obtained, and the transformer must also be low in cost, both of which conditions tend toward making the transformer of compact form.

Figure No. 1 shows geometrically how the cooling surface of a conductor varies with its cross section, and how the surface varies with volume. Assuming that unit volume requires unit surface, it is easily seen how the rate of increase of volume and surface varies.

Figure No. 2 shows comparatively the volume and cooling surfaces of 1, 10, 1000 and 10,000 kw. coils and core designed without ventilating spaces. The density in copper is kept the same throughout all sizes, while the core density varies according to practice in the design of shell type transformers from approximately 35,000 to 65,000 lines per square inch. The shapes of the transformers are kept as nearly uniform throughout as possible. In ordinary practice for the shell type transformer, the core is generally rectangular for the larger sizes, tapering down to a square for the small sizes. If the iron densities were the same throughout, all sizes, from 10 to 10,000 kw., would be considerably increased, and the cooling surface still further reduced. The cooling surface could also be varied by varying the flux density and physical proportioning.

Kw. Cap.	Total Watts Cu. & Fe.	Radiation Watts Sq. In.		Max. Temp. Rise (Outside by by Therm'tr)	Safe Rating	Densities		Total Flux
		Cu.	Fe.			Cu.	Fe.	
1	62	.25	.095	40° C	1 kw.	2000	35.000	.38
10	250	.59	.172	70	6.5 "	2000	40,000	1.1
100	1080	.91	.33	95	55.0 "	2000	45.000	3.5
1000	5600	2.	1.03	145	350.0 "	2000	55.000	11.
10000	24000	4.	1.43	210	2500.0 "	2000	65.000	35.

The 1,000 and 10,000 kw. sizes would burn out long before they reached the maximum temperature. The ratings of the transformers based on the 1 kw. temperature rise are as follows:

6.5, 52, 350 and 2,500 kw., respectively for the 10, 100, 1000 and 10,000 kw.

Figure No. 3 shows the comparative size and dimension of a standard 2000 kw., 25 cycle, 6600 volt alternator and natural cooled and artificially cooled (air blast) transformers of the same rating. The natural cooled transformer is designed with no ventilating ducts. The air blast is designed in accordance with standard practice. The operating densities of both are also according to standard practice.

Class and kw.	Total Loss	Outside Dimensions Working Material	Radiating Surface	Approx. Max. Temp. Rise
2000 kw. Alter.	73 kw.	15'x15'x2.5'	165,000	35° C.
2000 kw. AB.Trans.	24 kw.	4'x4.75'x3.5'	113.000	35° C.
2000 kw. ND Trans.	20 kw.	3.5'x4.25'x2.75'	13,000	200° C.

The early practice for obtaining large transformer capacities consisted chiefly in mounting several units in the same case. The Slattery Transformer Co., of Ft. Wayne, Ind., made a general practice of this method in the early 90's—mounting 2, 3 and as high as 6 units of from ½ to 2½ kw. capacity in one case. The Wagner Electric Mfg. Co. and the Westinghouse Electric & Manufacturing Co., also employed this method to some extent. The Wagner Company built the natural cooled transformers in 25, 50 and 100 kw. sizes, mounting two 12.5, two 25 and two 50 kw. in one case. They were designed for intermittent service operating at full loads from one to three hours. The operating temperatures were considerably above the present A.I.E.E. requirements for transformers for the same class of work. With the Westinghouse Company, this practice was in general employed in connection with high voltage work to reduce the voltage strain across each unit.

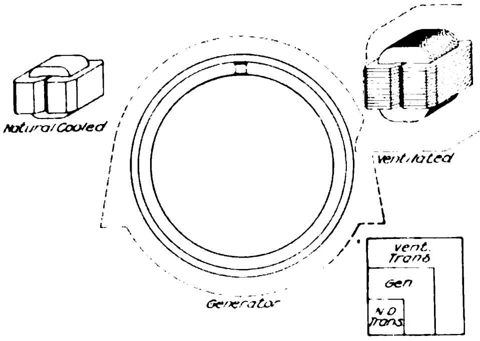


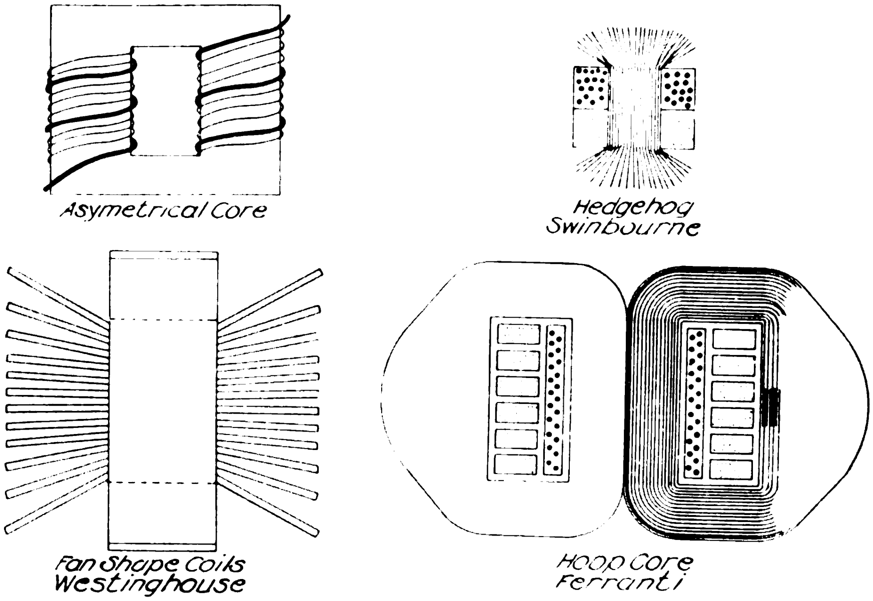
Fig. 3. Comparative Outlines of a 2000 Kw. Generator, Natural Cooled Transformer, and Ventilated Transformer.

It was several years after the oil transformer came into use before it was generally appreciated that considerably larger transformers could be built in single units and successfully cooled by the use of oil.

The Westinghouse Company and other prominent companies of that time, obtained large capacities by connecting several transformers of the same size and voltages in the same bank. From 1893 to 1895 in some of the large cities of this country it was a common sight to see banks of from 10 to 20 transformers, having a maximum size of 6¼ kw. suspended from the sides of fine buildings. In some instances, where compact grouping could not be obtained on account of windows or other obstruction the transformers had to be suspended singly or in pairs one above the other such banks often extending over two to three stories.

Early Consideration of The Thermal Problem

(a) By Varying Working Materials:


Asymetrical Core

Hedgehog Swinbourne

Fan Shape Coils Westinghouse

Hoop Core Ferranti

Fig. 4 Early Types of Transformers.

Probably the first effort to reduce transformer heat was by varying the proportions of the working material. One of the early designs along this line was Swinburne's "hedgehog" transformer. This transformer was the outcome of the theory that the heat due to iron loss was more serious than that due to the C²R, as the iron loss was continuous. The hedgehog transformer consisted of a core of iron wire formed into a bundle, around which there was wound a primary and secondary coil, side by side. The wires of the core projected beyond the coils and were bent over at the end as shown in chart No. 4. This transformer was of necessity mounted in earthenware jars or cases. On account of the open magnetic circuit, a case of iron would have been magnetized by the heavy leakage fields, causing high eddy losses and increased heat, which it was sought to avoid. This transformer was never popular on account of its poor regulation.

Early in the 90's, a French engineer proportioned the magnetic circuit of his transformer so that the part surrounded by the coil was of greater cross section than the yoke. The purpose of this was to reduce the loss and heat in that section which was not exposed to the air. This is what is known as the "asymetrical core" transformer.

About the same time the Thomson-Houston Company introduced the method of insulating the laminae of the core by a coating of insulating paint, and on some transformers built during this period, barriers of zinc were inserted in the core at short intervals to reduce eddy losses.

Westinghouse Great Barrington Transformers, (1886) were perhaps the first made in the United States in which the laminations were insulated by paper.

(b) By Internal Ventilation:

Thomson, Westinghouse and Ferranti were, perhaps, the first engineers who appreciated the importance of thoroughly ventilating all working parts of the transformer, and to them great credit is due.

In 1887 George Westinghouse was granted a patent on spacing or ventilating strips in core and coils. Spacing strips in coils had, however, been used abroad shortly before this time, but had not been patented in this country.

About the same time Ferranti designed his well known "hoop core" transformer, on which he was granted United States patent in 1888. This transformer is shown on Figure No. 4 and consists of several bundles of hoop iron each separated by spacing strips to allow ducts for cooling. The primary coils were wound on a separate form and were larger than the secondary, so that they would readily slip over them and allow a spacing or duct of ¼ to ⅜ in. between coils for the escape of heat. After the coils were all in place, the projecting ends of the hoop iron were bent over the coils half around the top and half around the bottom, the ends meeting and overlapping for a short distance. The features of the transformer were ease of building and provision for ventilating coils and core.

To be Continued.

TROLLEY SYSTEM AND CABLE REEL FOR ELECTRIC MINE LOCOMOTIVES.

By W. C. LANCASTER.

In the tunnels under Manhattan, which are being built for the Pennsylvania, New York & Long Island Railroad, by the United Engineering & Contracting Company, Electric Mine Locomotives are used for hauling train-loads of rock from the headings back to the shafts.

There are two twin tunnels, each one mile long, and for nearly the whole distance through solid rock. The excavated matter is hoisted to the surface through shafts. There are two shafts for each tunnel, one being located at the half-way point, from which the work progresses both East and West, and the other at the Eastern terminal where the tunnels join the East River tubes, the work progressing West to meet the East headings, being driven from the center shafts. Thus there are six headings, three for each tunnel.

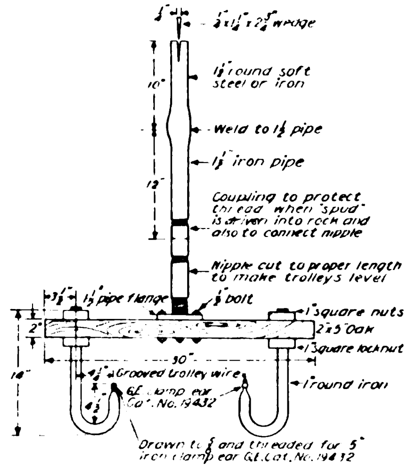

½"
½" x 1¼" x 2¾" wedge
1½" round soft steel or iron
10"
Weld to 1½ pipe
1½" iron pipe
12"
Coupling to protect thread when "spud" is driven into rock and also to connect nipple
Nipple cut to proper length to make trolleys level
3½"
1½" pipe flange
½" bolt
1" square nuts
2"
2" x 5" Oak
1" square locknut
30"
14"
4½" Grooved trolley wire
GE clamp ear Cat. No. 19432
4½"
1" round iron
Drawn to ⅝ and threaded for 5" iron clamp ear G.E. Cat. No. 19432

Fig. 1. Trolley Hanger.

One L M 104-D-1, ten-ton, Electric Mine Locomotive is provided for each heading. Each locomotive is equipped with two G.E. 59-A 230 volt motors, one R 37-C Controller, and a "cable reel device". The power is furnished by the New York Edison Company from their Edison three-wire system, 240-120 volts. The neutral of their system is grounded, making it necessary to use a double trolley for the Locomotives.

This trolley has to be kept back from the headings about 150 feet, in order to avoid the danger of its being hit by rock from a blast. Immediately after a blast, however, it is necessary for the locomotive to run up close to the heading to pick up its train of loaded cars, making a cable reel indispensable.

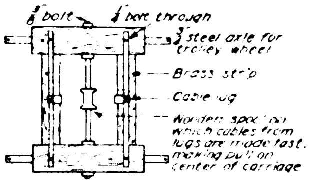

3/8 bolt
1/4 bolt through
3/4 steel axle for trolley wheel
Brass strip
Cable lug
Wooden spool on which cables from lugs are made fast, making pull on center of carriage

Fig. 2. Carriage.

It is also necessary for the locomotives to run on either of two parallel tracks, on both of which there are several switches. This meant a very large amount of overhead construction, if the usual trolley had been used, since there must have been a double trolley over each track and over all the switches. In addition to this, the switches have to be moved so frequently that the labor of moving the trolley frogs, crossings, etc. would have been very great indeed, and the delay caused by this practically prohibitive.

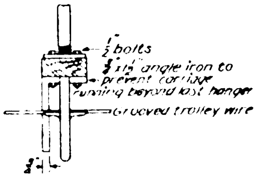

1/2 bolts
3/8 x 1 1/2 angle iron to prevent carriage running beyond last hanger
Grooved trolley wire
3/8

Fig. 3. Carriage Stop.

So much overhead construction too, meant an increased chance of rock from "trimming" blasts damaging the trolleys. These blasts are made some distance back of the headings and take off any rock left projecting inside the neat-line of the tunnel.

In order to reduce as much as possible both the cost and delay due to installing and repairing trolleys, the system shown in figure 1 was devised. Any blacksmith can make the "spud", as the 10-inch piece of round iron 1½ inches in diameter, welded on to a piece of 1½ inch iron pipe 12 inches long, is called. This "spud", with a wedge placed in the end, is driven into a hole about 7 inches deep, drilled in the rock-roof of the tunnel. When the wedge strikes the end of this hole, it causes the iron to spread, taking a firm hold of the rock. The roof being more or less uneven, a stock of assorted 1½ inch pipe nipples is kept, from which one is selected of the right length to bring the trolley to the proper level. The trolley fixture is next screwed on, and the No. 00 grooved trolley wires pulled up tight and clamped in the ears.

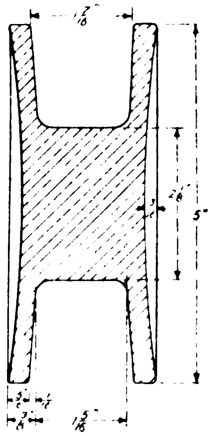
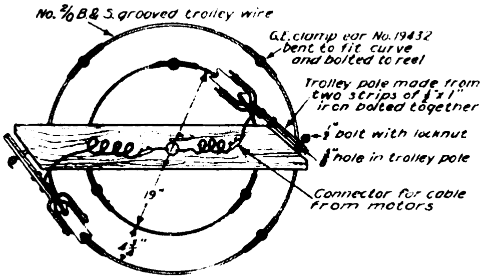

1 7/16"
2 1/8"
5"
3/16
5/16
1/16
7/16
1 5/16"

Fig. 4. Section of Carriage Wheel.

The carriage, shown in figure 2 is pulled along the top of these trolleys by the cable reel on the locomotive. Its four wheels are like that shown in section in figure 4. There is a strip of spring brass, not shown in figure 2, which presses against the side of the wheels, taking most of the current. The current also passes through the axles, as shown.

When the locomotive reaches the end of the line, the "carriage" is brought to a stop on the last trolley fixture, as shown in figure 3; the motorman throws his lever over a notch, and the cable reel plays out cable until the locomotive is as far into the heading as it is necessary for it to go. Returning, the cable is wound up until the locomotive is under the "carriage"; the lever is then placed at its original position, and the "carriage" runs back over the trolleys.



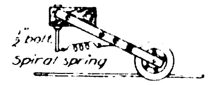
No. 2/0 B.& S. grooved trolley wire
G.E. clamp ear No. 19432 bent to fit curve and bolted to reel
Trolley pole made from two strips of ¼"x1" iron bolted together
⅜" bolt with locknut
⅜" hole in trolley pole
Connector for cable from motors
19"
4½"

Fig. 5. Collectors on Reel.

The locomotive runs equally well on any track, the flexible cable extending off sideways to the "carriage" on the one set of trolleys in the center of the tunnel. This system saves not only in copper and labor, but also the time which would be lost in changing over from trolley poles to the cable reel whenever the locomotive runs beyond the end of the trolleys.

It is rarely the case that two locomotives pass each other, but when this is necessary, it is easily and quickly accomplished by stopping a moment and exchanging "carriages"; the cable from the "carriages" being attached to the end of that on the cable reel, by a specially constructed copper hook and eye.

The cable reel device shown in figure 5 was installed on the reels about seven months ago, and not one has been touched for repairs since. The sketch explains itself.

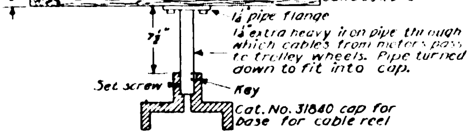


½" bolt
Spiral spring

Fig. 5. Collector Wheel on Reel.

Two concentric trolley wires, to the under side of which are fastened the ends of the cable on the reel, are held firmly by clamp ears, which are bolted to the top of the reel. These revolve with the reel, and under two trolley wheels which have both a vertical play and a slight side play. The motor cables are attached to these. This device is easily removed, allowing the reel to be taken off, and in case of breakage, can be easily and cheaply repaired.

It may be interesting to add that no steam is used in the construction of these tunnels. Air compressors, driven by 500 h.p. motors, furnish power for the rock drills and shovels; and all the hoists and other machinery are driven by motors. The apparatus is all General Electric.



2"
Oak 2"x5"x2'-9"
1¼" pipe flange
1¼" extra heavy iron pipe through which cables from motors pass to trolley wheels. Pipe turned down to fit into cap.
7½"
Set screw
Key
Cat. No. 31840 cap for base for cable reel

Fig. 6. Reel Support.

CONSTANTS OF CABLES AND MAGNETIC CONDUCTORS

III

By Ernst J. Berg

In paper II on "Line Constants, Etc." equations were given for the inductance and capacity of the parallel conductors used in transmission lines. The formulae given were sufficiently accurate for any transmission line calculations where the distance between wires is large compared with their diameters; where, however, the diameters are comparable with the distance, as is often the case with cable transmissions, it is necessary to use the strictly theoretical expression.

In looking up the available literature on this subject one is surprised at the great number of different formulae given. This is particularly the case in reference to the inductance formula which generally consists of two terms, one of which is constant and is usually given as .5, .75 or 1, the other a logarithmic function also variously expressed.

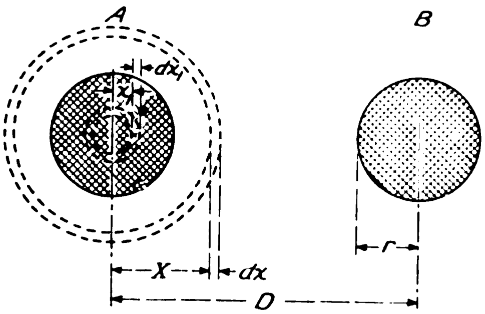


Fig. 1

Frequently the constant term is left out altogether, especially in formulae pertaining directly to standard line constructions.

To clear up the situation the following deductions are made, and a discussion added to show when the approximate formulae can properly be used.

A. and B. in Fig. 1 represent a couple of parallel cylinders of radius r and distance between centres D. For convenience in reasoning it is assumed that they are made up of a large number of strands or elements.

A current I flowing through conductor A will set up magnetic fields inside of the conductor and in the surrounding space. Consider at first the flux inside of the conductor.

The flux per unit length of line in section dx_1 is due to the current flowing inside of zone dx_1, which current is $\frac{x_1^2}{r^2}$ I.

Thus the M.M.F. per unit is $\dfrac{\frac{x_1^2}{r^2} I}{2\pi x_1}$

The field intensity is $4\pi \times$ M.M.F. $= \frac{2x_1 I}{r^2}$

Therefore the flux $\frac{2x_1 I\,dx}{r^2}$

The E. M. F. corresponding to this flux $= k \times \text{flux} \times \text{current} = \int_0^r k \times \frac{2x_1 I dx_1}{r^2} \times \frac{x_1^2}{r^2} I = k\frac{I^2}{2}$. The equivalent flux corresponding to this E. M. F. is $\frac{k I^2}{2kI} = \frac{I}{2}$, and therefore the equivalent inductance, which is $\frac{\text{flux}}{\text{current}} = \frac{1}{2}$.

The flux outside of the conductor is found in a similar way.

In that case the M. M. F. per unit length is $\frac{I}{2\pi x}$ the field intensity $4\pi\frac{I}{2\pi x} = \frac{2I}{x}$ and the flux

$$M_0 = \int_r^{D-r} \frac{2I}{x}\,dx = 2I\,({}^n\lg(D-r) - {}^n\lg r)$$

$$= 2I\,{}^n\lg\frac{D-r}{r}$$

The total flux expressed in C. G. S. units is therefore $M = I\left(2\,{}^n\lg\frac{D-r}{r} + \frac{1}{2}\right)$

and the inductance $L = \frac{M}{I} = 2\,{}^n\lg\frac{D-r}{r} + \frac{1}{2}$

Transforming this equation to practical units and expressing L in mil henrys per mile of conductor we get—

$$L = \frac{161}{10^3}\left(2\,{}^{n}\!\lg \frac{D-r}{r} + \frac{1}{2}\right)$$

In transmission lines D is usually large compared with r, so that the equation can be written—

$$L = \frac{161}{10^3}\left(2\,{}^{n}\!\lg \frac{2D}{d} + \frac{1}{2}\right)$$

where D is the distance between centres of wires and d their diameter.

Determination of Capacity Between Two Parallel Cylindrical Conductors

Let A and B in Fig. 2 represent two conductors charged with a certain amount of

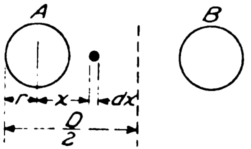


Fig. 2

electricity Q, A being positive + Q and B negative — Q.

Around each of these conductors is a field of stress, gradually decreasing towards zero potential plane.

The total field emanating from A is $4\pi Q$, thus the field intensity of an element at any distance x from A is $\frac{4\pi Q}{2\pi x}$ or $\frac{2Q}{x}$

The corresponding field intensity due to the charge in B is $-\frac{4\pi Q}{2\pi\,(D-x)} = -\frac{2Q}{D-x}$, so that the resultant static field intensity or static potential is:—

$$\frac{2Q}{x} - \frac{-2Q}{D-x} = 2Q\left(\frac{1}{x} + \frac{1}{D-x}\right)$$

Consequently, in moving the element from the plane of zero potential to the surface of the conductor its potential rises to $\int_0^r 2Q\,dx\left(\frac{1}{x} + \frac{1}{D-x}\right)$ which integrated is $2Q\,{}^{n}\!\lg \frac{D-r}{r}$

The capacity, which is the ratio of charge to potential causing the charge, is therefore

$$C = \frac{Q}{2Q\,{}^{n}\!\lg \frac{D-r}{r}} = \frac{1}{2\,{}^{n}\!\lg \frac{D-r}{r}}$$

which in practical units is:

$$C = \frac{890\,k}{10^4\,{}^{n}\!\lg\, 2\,\frac{D-d}{d}}$$

where C is micro-farads per mile of conductor

k specific inductive capacity,

D distance between centres of wires,

d their diameter.

In transmission lines where K = 1, and 2D is large compared with d, the formula can sufficiently accurately be written as:

$$C = \frac{890}{10^4\,{}^{n}\!\lg \frac{2D}{d}}$$

Cables

With the present state of the art it would not be conservative to use a cable at more than 25,000 volts between conductors, although it is to be expected that at least with rubber covered cables, or cables with insulation of gradually decreasing specific inductive capacity, a higher voltage can finally be used.

At present time essentially, or almost entirely, two kinds of cables are used, one having paper insulation and the other rubber insulation, both being covered by lead.

Although the dielectric strength of paper is considerably less than that of rubber and therefore more insulation is needed due to the lesser cost, it is almost entirely used, and no doubt will remain so until cables for higher voltages are required.

It is almost impossible to give a general rule for the safe current capacity of a cable since it depends largely upon what kind of conduit is used, the relative amount of insulation, etc. Perhaps .025 watts per square inch radiating surface (outside) is as fair approximation as can be made. When however the cable is laid directly in soil 50% more current can be carried and when placed in water 100% more current seems safe. This last case corresponding to .1 watts per square inch. The actual rise in temperature in the conductor is then about 30° C.

On account of skin effect it is not desirable to use a conductor larger than about 1″ in diameter in 60 cycle circuits and one of 1½″ diameter in 25 cycle circuits, in which case the effective resistance is about 10% greater than the ohmic. The fact that the conductor is made up of a number of small wires does not materially lessen the skin effect, since the individual strands are not thoroughly intermixed, but each remains at the same distance from the centre at all times.

There is, however, for given outside diameter of the cable as compared with the outside diameter of the solid conductor, a slightly lesser skin effect in the case of the cable, due to the higher specific resistance of the cable, when considering the total cross section.

In other words, there is less conductivity for a given area of cable than in the same area of solid conductor, and since the skin effect depends upon the resistance per given area the skin effect must be reduced. The theoretical equations governing this phenomena are extremely complicated and are therefore omitted.

The inductance and capacity equations deduced apply directly as long as all conductors belonging to the same circuit are in the same conduit or cable. If, however, that is not the case, but as in a single conductor cable independent cables are used for the outgoing and incoming conductors "effective" values have to be calculated.

In the preceding were given the inductance and capacity formula for two parallel cylindrical conductors. In dealing with cables we require to consider the inductance and capacity between concentric conductors, such as single conductor in lead covered cable where current is permitted to flow in the lead or concentric conductors in general. In that case the equations become

$$L_{mh} = \frac{370}{10^3} \, {}^{10}\log \frac{D}{d}$$

$$C_{mf} = \frac{770\ k}{10^4 \, {}^{10}\log \frac{D}{d}}$$

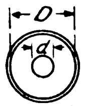


Fig. 3

Where L and C are respectively inductance in m. h. and capacity in m. f. per mile of conductor. Thus in a concentric single-phase cable in ½ mile of length of cable or in a three phase cable in 1 mile of length.

Effect of Grounded Lead Covering of Single Conductor Cables

The lead covering obviously acts as a short-circuited secondary to the EMF induced by the reactance of the line. It consumes some of the EMF therefore reduces the inductive drop but increases the ohmic loss due to the currents in the lead.

In calculating the phenomenon we will substitute for the line the primary of a transformer of same resistance as the line and with a magnetizing current the same as the line current at the voltage corresponding to the reactance EMF.

The reactance of the primary in this equivalent transformer is caused by the flux between lead covering and the conductor and is therefore as a rule quite small.

The secondary resistance corresponds to the resistance of the lead (which for given cross section is 14 times that of copper), the reactance is the same as that of the primary.

We can therefore diagramatically show these circuits as in Fig. 4.

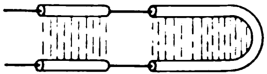


Fig. 4

The lead covering being grounded acts as a sheet of metal surrounding the conductor in inductive relation to the primary.

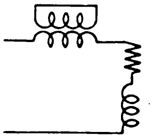


Fig. 5

Or as in Fig. 5, where the line resistance and reactance are assumed as concentrated in a transformer.

Or finally as in Fig. 6, as a combination of inductive circuits with the proper transformer constants.

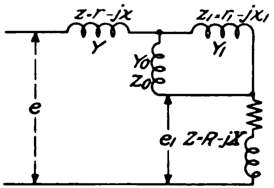


Fig. 6

Let $e =$ line voltage

$Z = R - j\ X =$ load impedance.

$z = r - j\ x =$ primary impedance.

where $r =$ line resistance.

$x =$ reactance between conductor and lead.

$z_1 = r_1 - jx_1 =$ secondary impedance where $r_1 =$ resistance of lead covering (For the same cross section 14 times that of copper.)

$Y_0 =$ primary admittance $= jb$ where

$$b \text{ is } \frac{I}{E_x} = \frac{1}{x_0} \text{ or } Y_0 = \frac{j}{x_0}$$

$x_0 =$ line reactance if no lead covering existed and a conductor of the same outside diam. as that of the lead covering was used in the calculations.

$$z_0 = \frac{1}{Y_0} = -\frac{j}{b} = -jx_0$$

Joint admittance of the two parallel circuits of impedance z_0 and z_1 is $Y_0 + Y_1 = Y_2$. The corresponding impedance $z_2 =$

$$\frac{1}{Y_0 + Y_1} = \frac{1}{\frac{j}{x_0} + \frac{1}{r_1}} \text{ since } x_1 \text{ is small}$$

$$\text{we have } z_2 = \frac{r_1 x_0}{jr_1 + x_0} = \frac{r_1 x_0\ (x_0 - jr_1)}{r_1^2 + x_0^2}$$

Total impedance is $= z_2 + z + Z$

$$\text{Current therefore} = \frac{e}{z_2 + z + Z}$$

$$\text{Voltage across load } e_1 = \frac{e\ Z}{z_2 + z + Z}$$

$$E_1' = \text{drop in line } e - \frac{eZ}{z_2 + z + Z} = \frac{e\,(z + z_2)}{Z + z + z_2}$$

Let $z + z_2 = z_3$

$$\text{We have then } E_1' = \frac{e\,z_3}{Z + z_3} \quad \ldots.A$$

In an ordinary line we have

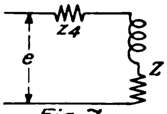


Fig. 7

$$\text{current} = \frac{e}{Z + z_4}.\ \text{Drop in line } E_1' = \frac{e\ z_4}{Z + z_4} \quad ..B$$

Comparing these two equations A and B, we see that if the values of line impedance obtained by writing $z_4 = z_3$ are inserted we can use the ordinary line equations

$$Z_4 = r_4 - jx_4.$$

From above we have—

$$Z_4 = z_3 = z + z_2 = \frac{r + r_1\ x_0^2}{r_1^2 + x_0^2} - j\left(\frac{x + r_1^2\ x_0}{r_1^2 + x_0^2}\right)$$

or neglecting x which is small we can write the effective resistance as $- \quad r + \frac{r_1 x_0^2}{r_1^2 + x_0^2}$

and the effective reactance $= \frac{r_1^2 x_0}{r_1^2 + x_0^2}$

As a rule x_0 is small compared with r_1 and we can write

$$\text{effective resistance} = r + \frac{x_0^2}{r_1}$$

$$\text{“} \quad \text{reactance} = x_0$$

When estimating the reactance and effective resistance of a grounded single conductor lead clovered cable—calculate the ohmic resistance r of the conductor, the ohmic resistance r_1 of the lead covering, (specific resistance 14 times that of copper) determine the reactance x_0 as between two parallel conductors of same diameter as the outside diameter of the lead, and substitute the values so obtained in the equations given above.

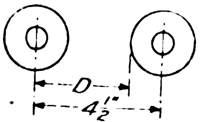


Fig. 8

Instance:

Two cables of 1000 ft. total length placed on 4½ in. centres, each cable contains a 0000 B&S conductor. Outside diameter of lead 1 in., inside diameter ¾ in. What is the effective resistance and reactance of 25 and 60 cycles?

$r = .049$, area of lead $\frac{1}{8} \pi \frac{7}{8} = 0.343$ sq. in.

corresponding to copper section $= \frac{.343}{14}$

$= 0.0245$ sq. in.

Therefore $r_1 = .332$

At 25 cycles reactance outside of lead is $\frac{2\pi 25}{10^3} \times \frac{161}{10^3} \left(2^n \lg \frac{8}{1} + \frac{1}{2} \right) \frac{1}{5.28} = .0223$ ohms.

Therefore effective resistance

$= .049 + \frac{.0223^2}{.332} = .0505$ ohms.

At 60 cycles the reactance is 0.0535.

Therefore effective resistance = 0.0572.

The resistance is increased 3% in the first case, 16% in the latter.

To illustrate the increased loss in a single conductor lead covered cable, table A has been prepared. It applies to a single conductor cable No. 0000 B. & S. having a lead covering $^1/_{16}$ in. thick, the outside diameter of the lead covering is 1 in. Losses are given for various distances to return conductor and at various frequencies.

It shows that in general the losses introduced are small and need only be considered in 60 cycle systems when the cables are considerable distance apart. This table refers to one mile of conductor.

Cycles	12.5			
Distance inches	2.13	4	12	24
r	.264	.264	.264	.264
$x_0 = x_e$	.0249	.0458	.0772	.0952
x_2''	.0006	.0021	.0059	.009
r_e	.2642	.2649	.2665	.2678
Increase	.1%	.34%	.98%	1.4%

Cycles	25			
Distance inches	2.13	4	12	24
r	.264	.264	.264	.264
$x_0 = x_e$	.0497	.0916	.1544	.1904
x_0^2	.0025	.0084	.0238	.0362
r_e	.2651	.2676	.2743	.2796
Increase	.42%	1.37%	3.9%	5.9%

Cycles	60			
Dist. inches	2.13	4	12	24
r	.264	.264	.264	.264
$x_0 = x_e$	.1193	.220	.3706	.4570
x_0^2	.0142	.048	.137	.208
r_e	.2701	.2848	.3233	.3536
Increase	2.3%	7.9%	22.5%	33.9%

Effect of a Not Grounded Lead Covering in Single Conductor Lead Cable

Since there is a difference in flux between the inside and the outside half of the lead covering, currents must flow alongside the covering in one direction in the inside half, in the other direction in the outside half.

The average distance between centre of one conductor and the nearer half of the lead covering of the other conductor is

$$D - \frac{D_1}{4}$$

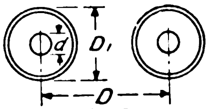


Fig. 9

The average distance to the outer half is

$$= D + \frac{D_1}{4}$$

The difference in inductance is therefore

$$l_d = \frac{742}{10^3}\left({}^{10}\log\frac{D + \frac{D_1}{4}}{d} - {}^{10}\log\frac{D - \frac{D_1}{4}}{d}\right)$$

$$= \frac{742}{10^3}\ {}^{10}\log\frac{D + \frac{D_1}{4}}{D - \frac{D_1}{4}}$$

Where l_d is expressed in mil henrys per mile of conductor.

With I current flowing in the conductor and the resistance of the lead covering calculated as above, that is a conductor of same length, as the conductor proper, and with the actual cross section of the lead, we get:

$$\text{Reactance E. M. F.} = \frac{2\pi n l_d I}{10^3}$$

$$\text{and eddy currents in lead} = \frac{2\pi n l_d I}{4 r_1 10^3}$$

$$\text{Thus the loss in the lead} = \frac{4\pi^2 n^2 l_d^2 I^2}{4 r_1 10^6}$$

Therefore the effective resistance

$$= r + \frac{n^2 l_d^2}{r_1 10^6}$$

Where n = frequency

l_d = inductance in mil henrys

r_1 = lead resistance — as defined above.

r = resistance of conductor proper.

With 4 in. distance between centres and one inch conductor, we get:

$$D + \frac{D_1}{4} = 4.25$$

$$D - \frac{D'}{4} = 3.75$$

$$l_d = \frac{742}{10^3}\ {}^{10}\log 1.13 = \frac{40}{10^3}\ \text{m. h.}$$

Therefore effective resistance

$$= 0.049 + \frac{25^2 \times 40^2}{0.33 \times 10^6 \times 10^5} =$$

.04903. We see from this that the eddies in a single conductor lead covered cable are negligible if the lead is not grounded.

Effect of Iron Armoured Single Conductor Cable

If the cable instead of being covered by lead was covered by a magnetic material such as iron, the problem is more complicated on account of the increased flux due to the iron. Such conduit is indeed quite out of the question on account of the increased reactance and eddy losses.

From the saturation curve of the iron it is possible to determine the magnetic density and therefrom the flux in the iron for a given current in the conductor.

Assume this flux to be M

E, the E.M.F. corresponding to this flux is

$$\frac{4.44 \times M \times n}{10^8}$$

The corresponding reactance is $\frac{E}{I}$ which reactance should be added to the normal reactance as obtained in a non-magnetic system.

The hysteresis loss corresponding to this density is found from the hysteresis curves of the iron and this loss divided by I^2 gives an equivalent resistance which should be added to the resistance as obtained in case of a non-magnetic conduit.

As an instance. Assume the cable described above covered by iron instead of lead, and that 150 amps. are flowing in the main conductor.

Assume further that the iron is $\frac{1}{8}$ in. thick and that the total loss due to eddies and hysteresis is 5 times as great as the hysteresis loss proper.

The M. M. F. available is $150 \sqrt{2} = 212$ AT

The Magnetic length is $\frac{7}{8} \pi = 2.75$

$$\text{M. M. F. per 1 inch} = \frac{212}{2.75} = 77$$

This corresponds to a density of 100,000 lines per sq. in.

The magnetic cross section $= 1000 \times 12 \times \frac{1}{8} = 1500$ sq. in.

Therefore the total flux $M = 150{,}000{,}000$ and $E = 166$ volts, the reactance due to iron is thus $\frac{166}{150} = 1.1$ ohms.

From hysteresis curve we find the loss per cubic inch per cycle $= .028$ watts.

Therefore the loss is $.028 \times 5 \times 1500 \times \frac{7}{8} \times \pi \times 25 = 14500$ watts.

Whereas the I^2R proper is but $150^2 \times .049 = 1100$ watts.

It can readily be proven that even the thinnest iron covering is prohibitive in single conductor cables for alternating currents.

In concluding the discussion of the effect of armour we may add that where two or more conductors involving a complete circuit are carried in the same conduit, it matters not whether the covering is of iron or lead, grounded or not grounded. The effect of the covering on the resistance or the reactance is negligible.

Iron Wire & Cables Used as Electrical Conductors

Since the ohmic resistance and permeability of iron changes very considerably in different grades and since the permeability varies with the current, it is evident that it is very difficult to lay down any definite rules regarding the effective resistance and reactance. So that, in order to get accurate determinations it is necessary to test samples of the conductor intended to be used.

With the present price of copper wire, it is evident however that wherever small power is carried relatively short distances at high voltages, iron wire, or at least iron cables, could be used, and calculations must be made before the actual wire has been secured.

With direct current the matter is fairly simple, since the permeability does not enter and wires of definite resistance could be ordered. This resistance in iron wire varies from say 4 times that of copper to 7 or 8 times that of copper.

With alternating current the skin effect causes additional resistance, which, at least in large conductors, is considerable, often several times that of the true ohmic resistance. This effect is however small in small wires, say wires of number 8 to 12 B. & S. gauge, but with large wires it is considerable. Such small wires can however not well be used for transmission lines for mechanical reasons. Therefore, it seems probable that stranded cables only need to be considered.

From a number of deductions it would seem as if the effective resistance of such stranded cable (7 strand cable) could be expressed by the following formula:

$$R = r + \frac{K\ N\ B^2\ D^2}{r\ 10^5}$$

In which K depends upon the permeability and may average 2.

$R =$ effective resistance per mile of cable

$r =$ ohmic resistance.

$N =$ frequency

$B =$ current density in amperes per square inch superficial area.

$D =$ external diameter of the cable.

The reactance can be approximated as:

$$X = x + 0.01N + \frac{K\ N\ B^2\ D^2}{r \times 10^5}$$

Where X = effective reactance per mile of wire

x = reactance as obtained if the cable were made of copper.

These formfulas apply fairly well at least to cables of from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. external diameter. It is unlikely that larger cables will be used since the skin effect is very considerable with $\frac{1}{2}$ in. cables, and it is unlikely that smaller cables will be used on account of mechanical reasons.

It is to be noted in connection with these formulas that the reactance as a rule is not prohibitive by the use of iron cables. It has often been thought that the reactance was the limiting feature, but this is not the case—the effective resistance is of more importance.

When using very large iron or steel conductors, such as rails in the case of single phase railroading, the effective resistance can be estimated from the degree of penetration or current, and this has been approximated by Steinmetz and others to be

$$\delta = \frac{2000}{\sqrt{g\ \mu\ N}}$$

Where δ, the penetration, is expressed in inches

g = electrical conductivity, which with soft iron is about 110,000, μ is the permeability and might be about 500 and N is the frequency.

Consequently, the resistance of such large iron and steel conductors is not depending upon the actual cross section, but upon the perimeter. It is furthermore proportional to the square root of the frequency.

EXPERIENCES OF AN ELECTRIC HEATING SALESMAN.

By Errett L. Callahan

The few salesmen, who are taking up this important subject, soon realize that it is interesting and attractive, requiring a high order of salesmanship and some acquaintance with the culinary art.

Having had considerable experience in selling electric heating devices to the consumer, and in interesting central station managers, contract agents and their solicitors in the ways and means of presenting the merits of the devices to the customer. I will give some of my experiences.

It is amusing to hear nearly every central station man say when first approached on the subject: "The people of *this* city are different from those of any other city." He will then tell you how easy it would be to sell heating devices in any other city than his own, for he thinks they do not have enough "wealthy residents" or that people will not spend the money for "luxuries" or "it is hard enough to get people to use electric light and pay their small lighting bills without kicking." These and a score of objections to pushing the sale of heating devices will confront the salesman on his first visit to a central station.

This, however, is a good introduction, for you have what he considers reasons preventing the getting of this profitable business, and by persevering you can surely convince him that he can get this business even if he has to start the missionary work of teaching the people of his town that they are not entering into the full enjoyment of life unless they have an electric iron, a coffee percolator and a heating pad; that they are not up to date without them; that the operating cost is in proportion to the benefit derived, but is not exorbitant. He must endeavor to popularize the use of things electrical.

A central station manager in one of our large western cities promptly turned me down when I first met him, saying that while he would like to have the business I pictured to him, he could not afford to lose the friendship of the electric supply houses who favored him in business by not encouraging private plants. It took two days to get this man to see that he would be building up *their* business, and that after he got the business established there would be a demand for heating devices, which business he could turn over to them if he wanted to. Now he is one of the most active in pushing the heating business, having five young men solicitors on heating alone.

In another city where there was a gas and electric company, the superintendent of the electric department was enthusiastic over the prospect of an increased day load, but the commercial department manager, a "dyed in the wool" gas man, kept me half a day in argument as to the "certain decrease" of the monthly gas bills. I received a nice order for irons and later it was estimated by the gas man himself that the decrease in gas receipts was approximately 1½ per cent.

At pure food shows and electrical shows the local lighting company is the center of attraction, especially if it is a combination gas and electric company. People here indicate the need of education as to the use of electric conveniences when they believe that lightning is sure to strike their houses if they use electricity—expect to use electric irons on annunciator circuits, and receive electric shocks from touching any electric apparatus. It seems hard for many people to understand that when a device is connected to an ordinary lamp socket it may take more current than the ordinary incandescent lamp.

I asked a contract agent the other day how it was that his solicitor made so many flat irons "stick." "Well," he said, "I tell the collector to never bring an iron back. If the party wants to return it for any reason, he tells him to go on using it until we send up someone to get it."

It is sometimes hard to close large orders. Your prospective customer wants the business, and while it seems easy to turn heating devices into a profitable day load, he hesitates in placing the order. I remember an instance of this kind. We had "talked it over" and over, but could not get down to business. Finally I jumped up, looked at my watch, and remarked that by hustling I could get the train, and that I was going to telegraph our company to ship 500 irons at once and 500 more in five months. It worked.

Last spring I spent a very interesting day examining the fire apparatus in No. 4 engine house in a Michigan city, while the City Inspector and the Fire Marshall of the city examined and tested my trunk full of devices, with the result that their letters to the electric light company were so favorable to the use of the devices on the company's lines without making special installations, that I had no trouble in getting a nice order before dinner that night.

The other day I heard that a certain colored woman who did the washing and ironing in a home had stopped work because "dat electrical ion done make ma arm paralyzed." It appears that, being afraid to disconnect the iron from the circuit by pulling off the plug, she had to work so fast that she would get through in half the ordinary time—she was afraid of overworking.

At one time in Dubuque, Iowa, before a company of ladies, the writer was giving a little talk on Twentieth Century Comforts, and just after accomplishing the well known "stunt" of steam cooking an egg in 3½ minutes, using one teaspoonful of water, a lady spoke up and said: "But eggs are not healthful when cooked so quickly; they should be put in water that has been brought to a boil and left eight minutes." It looked for a moment as though she had scored a point, but I explained further that the electric cooker is perfectly adapted to the slower plan if preferred. As a matter of fact eggs are usually cooked by the quickest possible method.

I have found that a trunk of samples will go a long way toward inducing a central station man to take up the line, even though he has seen all the devices. I manage to get a few minutes of his time to look at what I have on the assumption that I have something *new*, and that I will take but three minutes of his time, if he seems adverse to taking up the sale of heating devices. Many a time I have received a good large order by showing the contents of this trunk when there seemed little or no chance of getting one otherwise. Most of us after all "are from Missouri."

A central station manager in the natural gas belt was very loath to continue pushing the sale of heating devices after the gas was piped into his city, saying that it would be impossible to get more, or even keep the heating business he had with gas at 25 cents per 1000 ft. He told me not a month ago that his electric heating business instead of falling off, except for two or three months at first, had increased at a greater rate than it ever did before, and that even this winter there has been a demand for electric irons. This is the second winter for the gas, and together with poor gas service and the necessity of re-decorating the interior of houses, there is a reaction in favor of the clean illuminant and power for heating.

My experience has shown me that in the majority of central stations where preliminary work has been done as an introduction to a real heating campaign, the managers are ready to vigorously push the sale of heating devices this spring; therefore, I believe that we can expect a very prosperous year for heating devices.

NOTES.

Mr. G. H. Calkins assumed charge of the Buffalo Sub-Office on Monday, March 18th, vice H. H. Crowell, resigned. Mr. L. H. Lewis succeeds Mr. Calkins in charge of the New Haven Sub-Office.

* * *

The business of the Consolidated Railway and of the New York, New Haven & Hartford Railroad will be handled as heretofore by a separate representative of the company stationed at New Haven. Mr. H. D. Hawks is now in charge, having succeeded Mr. R. C. Jeffcott, who is on leave of absence.

* * *

Mr. W. D. Jennings has succeeded Mr. Lewis as Supply Salesman in Connecticut. Mr. H. C. Van Weelden replacing Mr. Jennings as Supply Salesman on Long Island, the remaining territory formerly covered by Mr. Jennings.

* * *

Mr. H. H. Barnes, Jr., until recently in charge of the Engineering staff of the Stanley-GI Electric Mfg. Company, at Pittsfield, Mass., under Mr. Chesney, has entered the employ of the New York office, succeeding Mr. Calvin W. Rice, as Consulting Engineer. Mr. Rice has left the employ of the Company to become Secretary of the American Society of Mechanical Engineers.

* * *

Mr. Andrew Kidd, Jr., until recently an engineer under Mr. Maxwell Day, in the Power and Mining Engineering Department, has entered the Estimating Department of the New York Office.

* * *

Mr. D. S. Smith, until recently attached to the Engineering Department of the New York Office, has left the Company on temporary service with the Bureau of Equipment at the New York Navy Yard.

Mr. R. A. Jenks, Salesman in the Small Motor Department, of the New York Office, will leave the Company on March 16th, to enter the employ of the Holtzer-Cabot Company.

* * *

On March 9th a very interesting and instructive meeting of about thirty representatives of the New York Office was addressed by Mr. Richard H. Rice, on the subject of Small Turbines.

* * *

Mr. E. Douglas, who was for many years connected with the Construction Department at Schenectady, and who was recently a member of the sales force attached to the Buffalo Office, has entered the employ of the Operating Department of the Electric Bond and Share Company. He is succeeded by Mr. H. C. Smith, formerly of the Atlanta Office.

* * *

Mr. F. F. Barbour has resigned his position as Manager of the Sales Department of the San Francisco Office, to take up special work in the line of Railway and Turbine apparatus. He has been succeeded by Mr. H. S. Russell.

* * *

Prof. J. P. Jackson, of the Pennsylvania State College, together with twenty-five Seniors of the Electrical Engineering Course, spent March 21st in inspecting the General Electric Works at Schenectady. Several of the party have accepted positions on the "Test" and will report for duty after graduation next June.

On Wednesday and Thursday, March 27th and 28th, a portion of the graduating class in Electrical Engineering at the Massachusetts Institute of Technology also visited the Works of the Company. Prof. Geo. C. Shaad, a former employee of the General Electric Co., being in charge of the party. Several of these men also have made application for employment in the Testing Department.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Schenectady Branch.

The first meeting in March was held upon Friday, the 8th, and was devoted to a smoker.

Mr. G. W. Cravens, who acted as Master of Ceremonies, stated that Dr. Steinmetz, who was to have spoken, was unable to be present, and introduced Mr. D. B. Rushmore as the first speaker of the evening.

Mr. Rushmore confined his remarks to matters pertaining to the affairs of the Branch. In this connection he mentioned a recent discussion which took place at the Parent Body in New York, upon the subject of branch development, and said that it was extremely gratifying to learn that the Schenectady body is considered the banner branch. Mr. Rushmore said that it had been the intention to introduce more of a social element into the meetings, but that this had not as yet been satisfactorily accomplished, and that the demand seems to be for a lecture course. This, he feels, is unfortunate, and thinks that in addition to the social feature, the Branch should have the effect of developing speakers, and give rise to the presentation of original papers. He suggests that this might be accomplished by forming groups of members for the purpose of specializing to this end.

Mr. Rushmore mentioned the fact that the *General Electric Review* is glad to throw open its columns for the publication of such papers.

He spoke of the influence that can be exerted to form the spirit of the city, and cited the results already accomplished at the Albany Library.

In concluding his remarks, he stated that in making the plans for the ensuing year, the suggestions should emanate from the association as a whole, and asked that such members as have definite ideas in this connection, write them out for consideration.

Mr. Rushmore was followed by Mr. C. H. Hill, who sang, and who was accompanied by Mr. A. V. Thompson.

Mr. E. B. Merriam then gave an exhibition of illuminanted dumb bell swinging and was followed by Mr. E. B. Raymond, who spoke of the rapid development of the General Electric Company.

Twelve years ago, Mr. Raymond said, 3,700 men were employed in the Schenectady shops, whereas today the number employed by the General Electric Co. is over 15,000.

During the year of 1895, 56,000,000 pounds of apparatus were shipped, and in 1906, about five times that amount. The number of machine tools have increased in a like ratio, and their value has risen from one to four million dollars.

A 50 h.p. induction motor, ten years ago cost $600 and today can be made for about one-half of this sum, and whereas this was the largest size made at that time, the Company is now building them up to 6000 h.p.

He spoke also of the cycle of changes that had occurred in the matter of speed, and said that twelve years ago everything was high speed, but changed gradually to low speed, and has now returned to high speed again.

Among the advancements of recent years Mr. Raymond mentioned the great saving in core losses, and spoke of the improvement in the insulating preparation used for core laminations, it having twenty times the insulating properties of the old japan, with only 0.3 of a mil thickness (total on both sides).

The development of lamps and their increased efficiency was also touched upon.

The latter part of the evening was devoted to songs and stories by Messrs. Thompson, Atkinson, Morrow, Close and others, Mr. Emmons making a short speech. The evening closed with refreshments.

March 14th Mr. S. D. Sprong read a paper upon The System of the New York Edison Co., which was profusely illustrated by lantern slides. This paper, together with that by Mr. Richard Flemming upon Arc Lamps, which was read on March 21st, and Mr. C. W. Larsen's lecture of March 28th upon Mine Locomotives and Mining, we hope to publish in the next issue of the REVIEW.

QUESTIONS.

This section is open to inquiries upon engineering subjects. The questions will be submitted to the respective departments and such as are of general interest will be answered in this column, while those of less importance will be answered by letter.

(Q) Can Type H transformers be operated in multiple with other types supplied by a common primary and feeding a secondary net work?

(A) Such operation will not usually result disastrously to either type of transformer, provided they are not banked together on the same pole and the load is taken off between the two transformers. When two transformers are banked together on the same pole, they will divide their loads inversely as their impedences. If, however, the transformers are installed at some distance from each other, the load can be taken off at an intermediate point, such that the line drop between the load and the transformer serves to equalize it. Division of the load between transformers can be very readily checked by means of a General Electric cable testing current transformer and ammeter, which can be easily clamped around the transformer secondaries and the secondary current determined. If it is found that the load is unequally divided between transformers, the load tap can be shifted to a point nearer the transformer not taking its share of the load, or one transformer can be moved to a more distant point. In general, however, the best results will be obtained by the parallel operation of transformers of similar type. M.O.T.

* * *

(Q.) How does the viscosity of oil affect the satisfactory operation of oil switches, oil cooled transformers and oil lubricated bearings?

(A.) The viscosity of oil for its flowing property has a very considerable effect on its properties in oil switch work and oil cooled transformers, and a slight effect on its use and bearings.

Where oil has been subjected to over heating, it may be carbonized to such an extent that it becomes very thick and rapidly loses its running properties. In oil switch work this leads to a failure to rapidly follow up the motion of the switch blades when the switch is opened, with a consequent failure to extinguish the arc as rapidly as desirable.

In oil cooled transformers a thick oil will give a reduced cooling effect, since the convection currents by which the heat is conveyed from the interior winding to the casing will be more sluggish, and the heat will not be conveyed away so rapidly. In bearings, a thick and very viscous oil having in general a higher flash point, may be used. At the higher temperatures, this viscosity is rapidly reduced, which within certain limits results in more perfect lubdication. C. T. W.

* * *

Q. If an induction motor had one phase of the stator winding reversed, how would this affect its operation, and how would you proceed to test to be sure that this really was the cause of the trouble?

A. Take out the rotor of the induction motor, then locate the neutral point of the Y connection and connect to this point a D. C. source of supply (say, a standard lighting pressure of 120 volts). Then in turn connect each of the three terminals of the motor to the other terminal of the lighting circuit through a sufficient resistance to reduce the resulting current to a small fraction of the normal ampere capacity of the winding, and while this current is flowing take a small pocket compass and move it around inside the stator; this will indicate the polarity of each polar winding, and, if the two poles are found side by side of the same polarity, the trouble is discovered.

This will affect the operation of the induction motor by causing it to hum, to take an unbalanced current, and to fail to carry its load properly. C.T.W.

SALES NOTES.

The Jamestown Exposition, which is to open April 26th, has arranged to purchase their power from the Norfolk & Portsmouth Traction Company, who purchased 10,500 kw. of power station equipment from the General Electric Co. last year.

The Exposition Company has recently placed a contract with the General Electric Co. for 100,000 incandescent lamps, and will also lease the following equipment:

Five 5 kw., ten 10 kw., fifty 30 kw. and seventy 50 kw. transformers, the primaries of which are to be 1100/2200, and the secondaries 122/224.

Four motor generator sets, each set being composed of an I-12-175 h.p.-600-2080 volts three-phase induction motor, and

Two D. C. Generators CLB 6-55 kw. 625-125 volts, with rheostats.

Twelve 18 in. Searchlight projectors, and

Ten 30 in. Searchlight projectors.

* * *

The Forest City Railway Co., the new three cent fare line in Cleveland, Ohio, has recently entered an order for fifty-five 4-motor GE-80 equipments, and a few weeks afterward, a second order for fifty-five air brake equipments.

This line is at present operating fourteen miles of road in the city of Cleveland. It is the only city three-cent fare electric road in the United States at the present time.

The Municipal Traction Co., which operates this line upon a rental basis, is now conferring with the Cleveland Electric Railway, the other city road of Cleveland, with the idea of renting that line also.

* * *

The General Electric Co. has recently closed a contract with the Ludlum Steel & Spring Co., Pompton, Passaic Co., N. J., covering motors for their rolling mills at Watervliet, N. Y.

For the 9 in. mill there will be furnished a concatenated induction motor set consisting of an I-20-125 h.p.-240 r.p.m.-550 volt induction motor, and an I-16-40 h.p.-300 r.p.m.-form M 550 volt induction motor complete with fly wheel, base frame, bearing shaft, controller and resistance. By various combinations these motors may be operated at the following synchronous speeds and outputs:

Speed r.p.m.	Normal h.p.	Maximum h.p.	
300	40	80	Normal load 1-4 time
240	125	150	Practically constant
120	60	100	Normal load 1-2 time

Where speeds are required differing slightly from those given above, they may be obtained by rheostatic control, it being understood that in case the load is taken off, the motors under these conditions will speed up to their normal synchronous speed.

For the 18 in. mill, we are furnishing one I-18-175 h.p. 267 r.p.m.-form M-550 volt direct connected three bearing induction motor. This machine will be arranged for operating at approximately synchronous speed only. Each of the above motors are reversible and provision is made in the controlling equipment to reverse the motors if desired.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

Illustrated *
Profusely Illustrated **

Safety of Electrical Machinery

[Electrical Review. Feb. 23. 1907. p. 322 *]

A brief description of the First International Exposition of Safety Devices, held under the auspices of the American Institute of Social Service at the Museum of Natural History, New York City, January 29 to February 12, including illustration and description of eight appliances exhibited by the General Electric Company.

* * *

The Evansville, Suburban & Newburgh Railway

[St. Ry. Journal, March 16, 1907, p. 446*]

Interesting description of a small electrified steam road operating a total of about 28 miles of main line track, east of the Evansville, Ind., to Newburgh and to Boonville. The rolling stock consists of five motor cars, three of which are of the combination baggage and passenger type, and all of which are being equipped with four G. E. 56 motors, provided with K 14 controllers and type M control.

A feature of special interest mentioned is the fact that during almost two years of operation of the system by electricity, but one armature has been lost, and this case is thought to have been due to lightning.

* * *

Electric Locomotive for Illinois Traction Syndicate

[Street Railway Journal, March 16, 1907, p. 468*]

A 40 ton locomotive of the switching type, classified as a 404-E-80-4 GE-55-H machine, equipped with four G. E. 55-H motors and type M single unit control. The rated load of the motors of the locomotive will give a tractive effort at the rail head of 16800 lbs., and at the slipping point of the wheels the locomotive will develop 20000 lbs. tractive effort with a load on the motors slightly in excess of their rated amount.

Two of these locomotives were recently built by the General Electric Co. and the American Locomotive Co. for the Illinois Traction Syndicate.

Some of their principal dimensions and weights are as follows:

Length over all, 31 ft. 1 in.
Height over cab, 11 ft. 9 in.
Width over all, 9 ft. 6 in.
Rigid Wheel Base, 6 ft. 6 in.
Weight of electrical equipment, 27,500 lbs.
Weight without electrical equipment, 52,500 lbs.

Steel Passenger Car for N. Y. C. & H. R. R. R.

[American Engineer & Railroad Journal, March, 1907, p. 81**]

The all steel type passenger car for use in suburban service was adopted by the New York Central and Hudson R. R. in connection with the electrification of the Grand Central terminal, New York. These cars are being equipped with General Electric apparatus exclusively, and one hundred and twenty-five have already been built and delivered by the American Car & Foundry Co., while fifty-five additional cars of similar design, but not equipped with motors, are being built and delivered for use as trailers.

The article gives complete data and drawings of the motor cars, and also refers to a number of descriptions of steel passenger cars used on other roads, including: The New York Subway, The London Underground Ry., Long Island Suburban Division and The Philadelphia Subway.

* * *

Electric Drive in the Lignite Briquette Factory of the Lauchammer Company

[Elekrische Kraftbetriebe & Bahnen, Feb. 14, 1907, p. 87*]

The factory is being designed for a daily output of 330 tons, and is located near the surface pit, from which the lignite is being mined.

The power house includes two 700 kw. external rotating field, engine driven two-phase fly wheel alternators, and two 170 kw. revolving field, engine driven two-phase alternators, furnishing a 50 cycle current at 1430 volts between the leads of each phase. One of the large generators is generally sufficient for the main load, and is operated non-condensing, the steam being used for industrial purposes.

Thirty-six motors with an aggregate output of 500 h.p. are installed in the factory, and four motors with an output of 230 h.p. are installed in the mine for pump drive, etc.

The power house equipment also includes a 30 kw. 120 volt generator set for the operation of two industrial locomotives employed for transportation within the works.

For the lighting of the entire service 110 arc lamps, 1700 incandescent lamps are provided. In order to obtain good potential regulation, a Tirrill regulator is being used, and a figure is shown demonstrating its influence in keeping the potential at 126 volts with almost no fluctuation, whereas without the Tirrill regulator the potential fluctuates between 120 and 130 volts.

The power house equipment, as well as a large number of the motors for the operation of the various machines are of A. E. G. (German General Electric Co.) make.

The New Turbine Plant and Sub-Stations of the Potomac Electric Power Co., Washington, D. C.

[Street Ry. Journal, March 2, 1907, p. 378*]

The new steam turbine plant is located in Bennings, D. C., on the eastern branch of the Anacosta River, and is being designed to furnish current for lighting and power as well as railway purposes.

The present equipment includes two of the ultimate three 5000 kw. steam turbine units, and two 2000 kw. steam turbine units of the General Electric-Curtis base-condenser type. They furnish a 6600 volt, 25 cycle three-phase current to the four new sub-stations, the equipment of which latter includes 1000 kw. rotary converters for railway supply, and 500 kw. motor generator sets for lighting, as well as a 500 kw. frequency changer for changing the 6600 volt, 25 cycle current into 2400 volts and 60 cycles for commercial purposes.

* * *

The Shawinigan Falls Terminal Railway

[Western Electrician, Feb. 23, 1907, p. 176]

The Shawinigan Falls Terminal Railway has placed an order with the Canadian General Electric Company of Toronto, for a 600 h.p. single-phase electric locomotive to be operated over the lines of the Shawinigan Water & Power Co., for the purpose of moving the freight cars required for the large factories located at Shawinigan Falls.

* * *

Operating Features of the Chicago Freight Tunnels

[Western Electrician, Feb. 23, 1907, p. 163]

Description of the underground electric freight transportation system in Chicago operated by the Illinois Tunnel Company over a permanent track of about 40 miles length, using 65 electric locomotives on a 240 volt circuit, together with 590 cars.

The equipment includes G. E. locomotives of the modern mine locomotive type.

* * *

Illumination in the Boston Herald Office

[Western Electrician, March 2, 1907, p. 187*]
[Electrical World, March 2, 1907, p. 431]

An installation recently completed in the Boston Herald Building, which was planned by the Illuminating Engineering Dept. of the General Electric Company, in collaboration with the Manager and Engineer of the Herald Company. The equipment includes some 75 enclosed arc lamps with inverted diffusers, in addition to a great number of incandescent lamps.

The article shows reproductions from photographs which, in order to show the actual general effect of the illumination at night, have not been retouched.

INDEX

A. I. E. E., Branch Notes 156
Cables:
  Cables and Magnetic Conductors, Constants of, by E. J. Berg 146
Controllers and Control Systems:
  Multiple Unit Control for D. C. Motors, by G. H. Hill, Part I 127
Expositions and Exhibits:
  Jamestown Exposition, The. (Sales Note) 158
  Safety Devices, International Exposition of (Abstract). 159
Generating Plants:
  Potomac Electric Power Co., New Turbine Plant and Sub-stations of, Washington, D. C. (Abstract) 160
  Shawinigan Falls Terminal Railway (Abstract) 160
Griffin, Gen. Eugene. Obituary Notice 125
Heating Devices:
  Experiences of an Electric Heating Salesman, by E. L. Callahan 153
Lighting:
  Illumination of the Boston Herald Office (Abstract) .. 159
  (See also "Expositions and Exhibits.")
Locomotives:
  Locomotives for Illinois Traction Syndicate. (Abstract) 159
Mills, Steel:
  Ludlam Steel and Spring Co., Watervliet, N. Y. (Sales Note) 158
Mines and Mining:
  Trolley System and Reel for Electric Mine Locomotives, by W. C. Lancaster 143
Motor Drive:
  Lignite Briquette Factory of Lauchammer Co. (Abstract) 159
Notes 155
Obituary, Gen. Eugene Griffin 125
Questions 157
Salesman, Experiences of an Electric Heating, by E. L. Callahan 153
Salesmanship, by F. F. Barbour 135
Traction:
  Evansville Interurban and Newburg Railway (Abstract) 159
  Forest City Railway Co. (Sales Note) 158
  Multiple Unit Control for D. C. Motors, by G. H. Hill, Part I 127
  Shawinigan Falls Terminal Railway (Abstract) 160
  Steel Passenger Cars for N. Y. C. & H. R. R. (Abstract) 159
  (See also Locomotives).
Transformers:
  Thermal Problems of Static Transformers, by W. S. Moody, Part I 138
Transmission:
  Cables and Magnetic Conductors, Constants of, by E. J. Berg 146
Trolley System and Reel for Electric Mine Locomotives, by W. C. Lancaster 143
Tunnels:
  Chicago Freight Tunnel, Operating Features of the, (Abstract) 160
Turbines and Turbine Installations:
  Potomac Electric Power Co., New Turbine Plant and Sub-stations of the, (Abstract) 160

AUTHORS.

Barbour, F. F. Salesmanship 135
Berg, E. J., Constants of Cables and Magnetic Conductors. 146
Callahan, E. L., Experiences of an Electric Heating Salesman 153
Hill, G. H., Multiple Unit Control for D. C. Motors, Part I 127
Lancaster, W. C., Trolley System and Reel for Electric Mine Locomotives 143
Moody, W. S., Thermal Problems of Static Transformers, Part I 138

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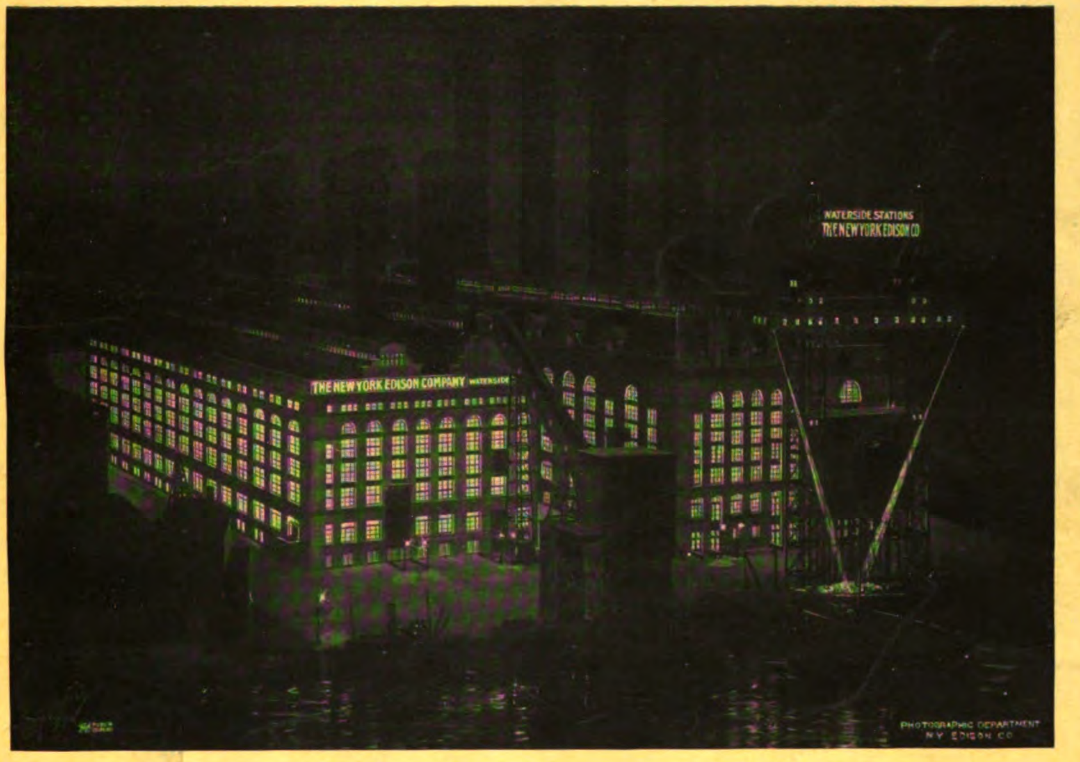

WATERSIDE STATIONS
THE NEW YORK EDISON CO
THE NEW YORK EDISON COMPANY WATERSIDE
PHOTOGRAPHIC DEPARTMENT
N.Y. EDISON CO.

Waterside Stations of the New York Edison Company

GENERAL ELECTRIC REVIEW

VOL. VIII NO. 6 MAY, 1907

CONTENTS

Page

The System of the New York Edison Company, Part I 161
By S. D. Sprong

Mining Locomotives in Coal Mines 169
By C. W. Larson

Recent Developments in Arc Lighting 173
By R. Flemming

The New Resistance Units 176
By C. D. Knight

Large Curtis Turbines in Chicago 178
By W. L. R. Emmet

Multiple Unit Control of D. C. Motors, Part II 179
By G. H. Hill

Thermal Problems of Static Transformers, Part II 189
By W. S. Moody

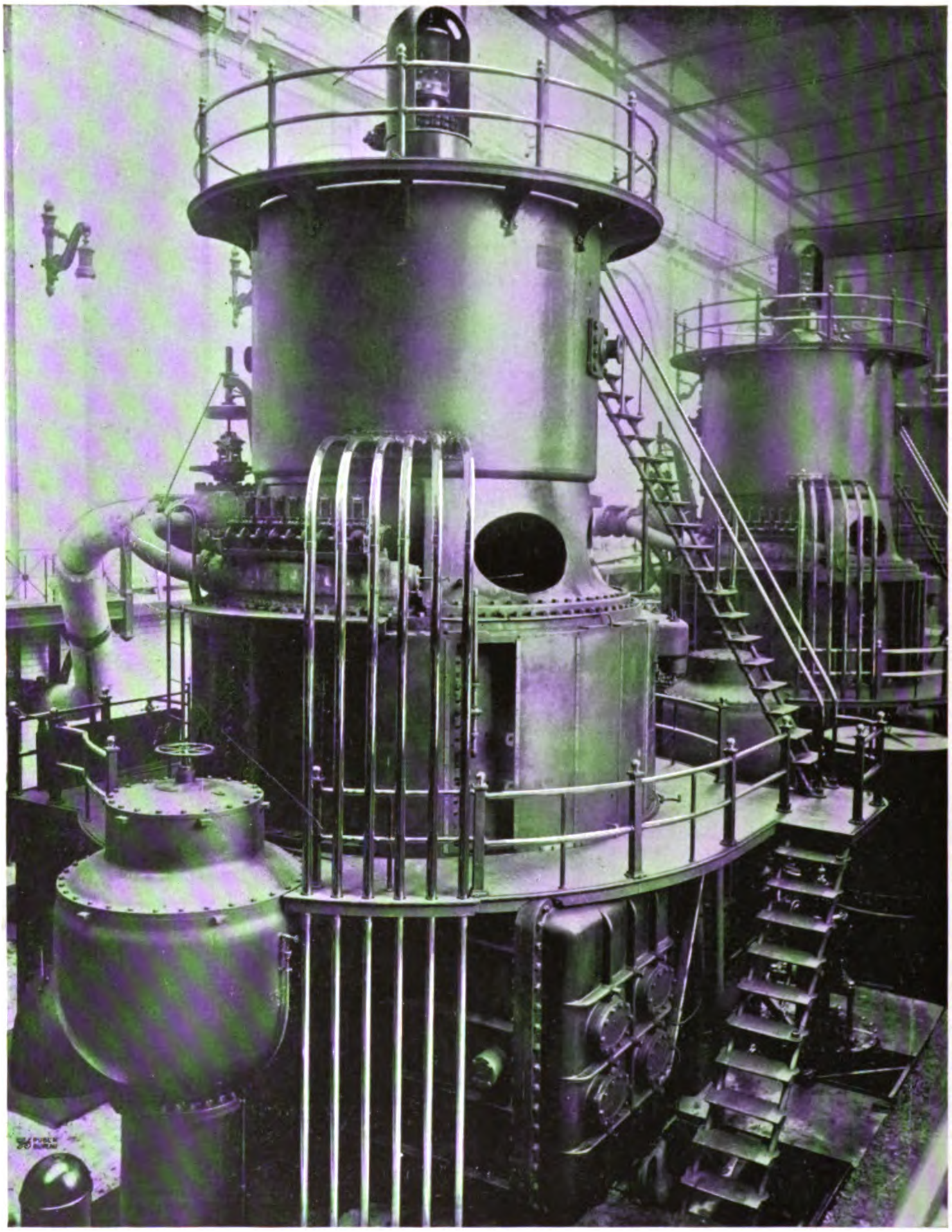
Mining Locomotives 195
By W. E. Brown

American Institute of Electrical Engineers, Schenectady Branch 197

Notes 198

Questions 199

Abstracts of Important Technical Articles 200



8000 Kw. Curtis Turbine-Generators
Commonwealth Electric Company, Chicago
(See Page 178)

VOL. VIII NO. 6 SCHENECTADY MAY, 1907

GENERAL ELECTRIC REVIEW

THE SYSTEM OF THE NEW YORK EDISON COMPANY

By S. D. SPRONG *

PART I

The modern tendency toward concentration in commercial affairs finds its engineering counterpart in the increasing number of large systems of centralized power generation and electrical distribution. In enterprises of this character there devolves on engineering a large measure of responsibility and obligation. It is justly held responsible for the character of the service rendered, and it has an obligation to maintain an absolutely continuous supply which is two-fold—that to the community as a whole, and to the customers individually. In its obligation to the community I refer broadly to its share in the police protection of the city. It is a matter for serious thought what something more than a momentary shut-down of the street lighting in a large city would mean. A little consid-

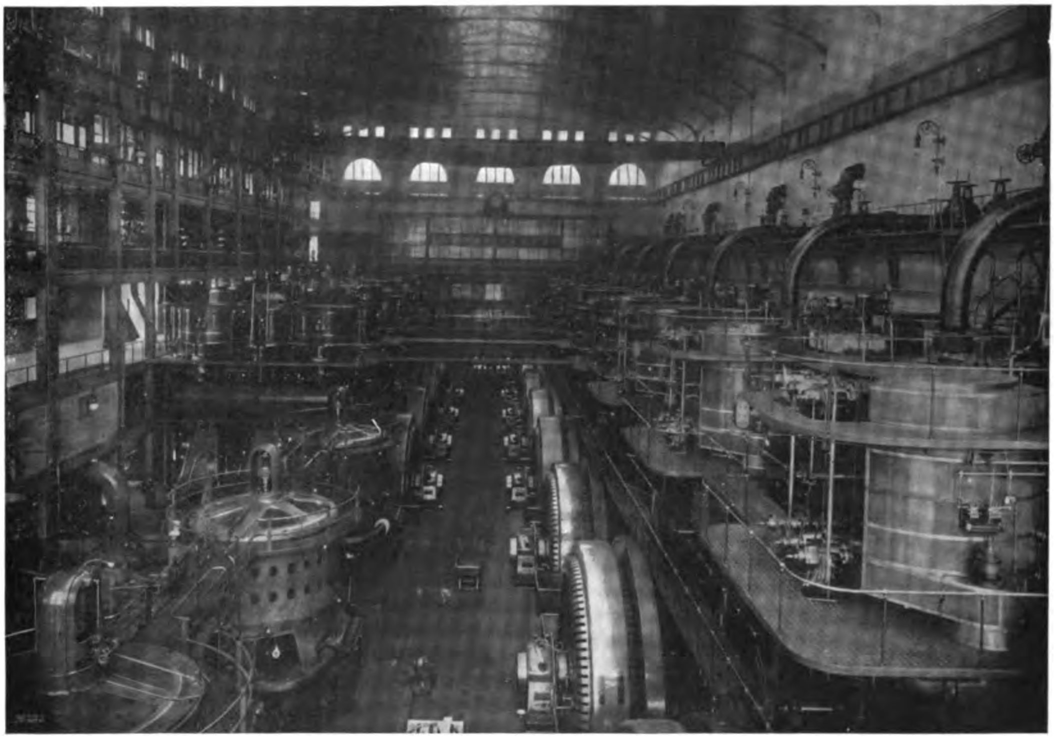


Fig. 1. Interior of Waterside Station Number One

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* Read before the Local Branch A. I. E. E.

eration will convince any one with a sense of responsibility, and an ambition to have a system measure up fully to its opportunities, as well as its obligations, that extreme measures are warranted to insure absolute continuity of service. Within the range of troubles incident to a power system, it might be taken as an axiom that anything which can happen may happen. The Engineer should therefore leave no known risk unprovided for, as there will always remain some that cannot be foreseen.

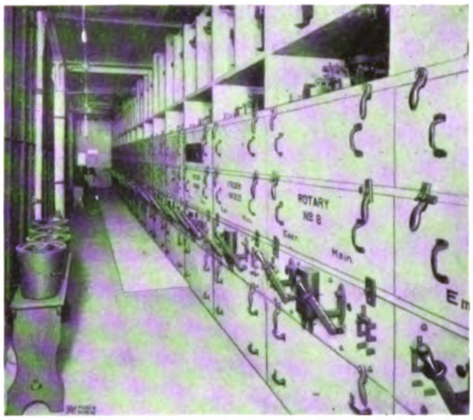

Fig. 2. General View of High Tension Compartments

The obligation of the company to its customer comprehends a number of important elements. The company should insure its customers courteous treatment; it should provide a service and all appurtenances thereto that will withstand any demand the customer may legitimately put on it, even under exceptional conditions; and last, but of the greatest importance, is continuity of service.

There is no engineering or commercial reason why a small plant should not give as reliable service as a large one under similar conditions, in fact, there are some engineering features in favor of the smaller system in that switches and other equipment can be had in capacities equal to the demands of any emergency, thus insuring positive results. This is not so in the case of the larger systems, and I think few will maintain that switching apparatus is available in capacities equal to the maximum demands that are sure to be placed on it under certain, but always possible emergencies. It is this generous factor of safety which gives the smaller system an advantage, and the lack of it which gives the engineers of the larger system one of the most serious problems they have to face. With the competitors, the gas companies, leaving aside the quality of their service, there is very little to be desired on the score of continuous supply, a fact which is true regardless of the size of the works. This point is illustrated very forcibly, although not always conspicuously, by the gas jets that we too frequently see burning in out of the way corners of stores and other places having electric illumination. There is an obvious reason, too often based on actual experience, for this precautionary use of

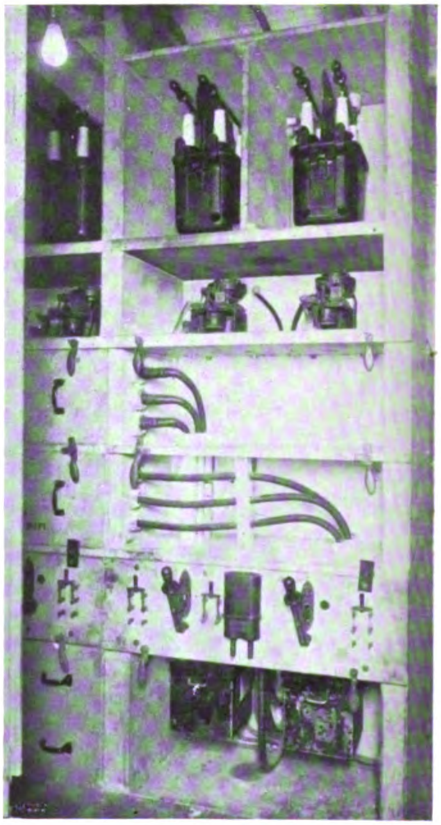

Fig. 3. Interior of High Tension Compartments

gas, and a pointed hint to those in charge of the electrical interests.

Attention, however, should be directed to the significant fact that in recent years, many important public places have been erected with only electric service available. This entire reliance on electric service is a testimony of the improvement in conditions over the past.

While you are generally familiar with the system of the New York Edison Company, which is the basis of these notes, a review of some of its distinctive features may be of interest. Structurally speaking, there are two main generating stations situated on adjacent city blocks between 38th and 40th Streets, First Avenue and the East River. The station between 38th and 39th Streets is the older, and is designated as Waterside No. 1; that between 39th and 40th Streets, as Waterside No. 2. The system of generation in both stations is 3-phase, 6600 volts, 25 cycles.

Waterside station No. 1 has a total *rated* generating capacity of 58,500 kw., and I might add that it has carried, at times, a load of 77,500 kw. The equipment is made up of eleven most conservatively rated 3500 kw. engine driven units, which have carried as high as 4500 kw. each, and four 5000 kw. turbine generators. The leads from the generators to the oil switches on the electrical galleries are carried entirely in conduit or brass pipe, each phase being run separately. The field leads are also in duct. As originally laid out, the generator cables were carried on a series of open steel shelves, all the cables of one generator being on their particular shelf. While this arrangement provided a steel barrier between the cables of any two generators, it was considered unsafe as there were no barriers between phases, and consequently there existed the possibility of a short-circuit in the open air. The shelves were therefore soon replaced by tile ducts. The bus ends of the generator cables terminate in an oil switch, across which the generator is synchronized. From the far side of this switch, cables lead to two oil switches in multiple, arranged as selectors to connect the generator to either the main or auxiliary buses. These switches are electrically interlocked, so that the buses cannot be connected accidentally, but the interlock may be easily removed for the purpose of transferring the loaded generators from one bus to the other without shutting them down. The generator switches are not connected to open automatically. For automatic overload they would have to be adjusted to a little above the short-circuit current of the generator, as, in case of accident, any generator may be called on for its ultimate current output, even at low voltage, for the important purpose of maintaining a fixed frequency with which to hold the synchronous substation apparatus together, and to provide a frequency with which fresh generators may be synchronized. Each generator has an overload relay, without time-limit, which lights a red lamp located on the generator panel. The lighting of the red lamp is supposed to indicate to the operator that that particular machine is overloaded, and therefore in trouble; but in practice this does not always prove to be the case. It frequently happens that when one generator becomes defective, it sets up more or less hunting between several machines, resulting in overload lamps light-

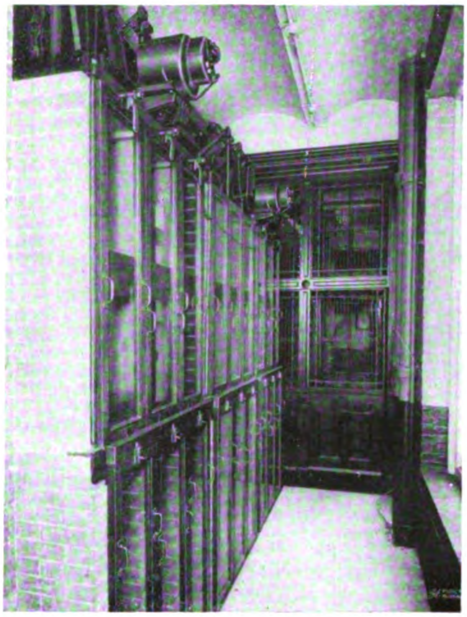

Fig. 4. Showing Interlocking Motor Operated Oil Switches

ing up here and there along the whole generator board; thus making it very difficult for the operator to pick out the defective machine.

The indicating wattmeters and ammeters swing violently across the scales, except those on the defective machine which stay at one or the other extreme, but just where the operator cannot determine, as the pointers are off the scales and out of sight under the case. This suggests that instruments should be so designed that the pointer cannot swing much beyond zero or full scale, and never out of sight.

The question has been suggested whether it is necessary, or even desirable, as a supplementary aid to the operator, to have the operating gallery so located that a full view of the generator room may be had.

In a number of instances in our experience the operator has been enabled, by observing the smoke coming from a defective generator, to promptly locate and disconnect it, regardless of the indications of the instruments, which could not have been taken as an accurate or prompt guide to the defective machine. Important mechanical troubles would be detected with equal promptness and facility. In a station with a small number of units this is not of much importance, as an operator can read all the generator loads at a glance, but with 10 to 15 generators this is impossible, therefore we have provided in both Waterside Stations for the fullest possible view of the engine room from the operators' gallery.

Our practice differs from that of some of the larger companies, as for example, the Chicago and the Boston Edison Companies, who have their switching equipment and control in a separate and detached switch house. This of course, effectively protects the operators against a steam break, but we obtain practically the same result by enclosing the gallery in such a manner as to make it secure against any disturbance of this character. Experience in the operation of Waterside Station for some years has convinced us that the advantage of this provision cannot be emphasized too strongly, and in fact, it has a value that cannot be obtained in any other way.

The fields of the generators in Waterside No. 1 are controlled by hand operated rheostats with all contacts on the front of the board, permitting easy inspection, and what is more important, the prompt detection of any trouble that may be developing at a point in the circuit which is by far the most liable to give trouble. In Waterside No. 2, consideration of space made it necessary to adopt remote controlled rheostat dials.

To insure an absolutely uninterrupted supply of excitation current, the system has been laid out on very conservative lines, both as to the specifications of the apparatus employed, and the provisions for alternative supply. The regular supply comes from a number of 150 kw. motor-generator sets, each of which is made up of a 6300 volt 3 phase induction motor, direct connected to a shunt wound 250 volt D. C. generator. There are four of these units in Waterside No. 1, and provision for a like number in Waterside No. 2. The total exciter generator capacity for each station is 600 kw., and it was subdivided to this extent so that the loss of one machine would overload the others but 33 per cent. The specifications under which these units were furnished, provides for a continuous run at 33 per cent. overload within a conservative temperature rise.

There is also installed in the Waterside stations, to supply the local section of the D. C. net work, a number of 500 kw. motor-generator sets, which, by inter-connection between the excitation and the system switchboards, may be promptly transferred for the supply of excitation current. All D. C. generators, when on the exciter bus, have reverse current instantaneous relays, so adjusted that a reverse flow of 25 per cent. full load current into a defective generator, will immediately open the circuit breaker, thus preventing any unusual demand on the exciter system.

Floating on the excitation bus, is a fully charged storage battery, having a capacity of 2000 amperes at 270 volts, at the one hour rate. It has the usual end-cell arrangement to maintain more uniform voltage, and if required, will furnish the excitation current for the entire station for about an hour. At a time when most of the generators were in use, the experiment was tried of instantly throwing all the excitation load on the battery by disconnecting the exciter generators, with the result that the voltage of the high tension bus did not drop sufficiently to attract the attention of the operators in any of the sub-stations. The equipment for the supply of the local D. C. net work previously referred to, includes a duplicate storage battery which may be thrown over on the excitation bus if required. It is occasionally used on the excitation bus for short periods, to relieve the regular excitation battery while the latter is out of service for cleaning or repairs. As a further possible source of supply, any of the feeders running out of the sub-station and tapping the underground system, may be transferred to the excitation bus and used as an incoming feeder, in the same manner as a service to some of our large customers.

To protect the excitation bus from accidental overload, it was necessary to employ instantaneous reverse relays on the generators. To avoid opening the relays by reverse current during depressions in the high tension bus, it was necessary to drive the generators by induction motors, as they will not invert under these conditions.

The exciter switchboards in both stations are of special design, the one in Waterside No. 2 being a refinement of our sub-station edgewise system to insure the maximum possible safety. The positive and negative sections are separated lengthwise of the board by the control section, the buses and connections of the same polarity being separated by barriers, front and back.

Current for all the switch control and signal systems is taken from the exciter system through two widely separated feeders, so that either can supply all the current required in case of injury to the other.

Turning to the high tension bus, it is in duplicate, or main and auxiliary, each of which is in two sections in Waterside No. 1 and in four sections in Waterside No. 2.

The high tension feeders are triplex, made up of three 250,000 c. m. conductors with 5/32 in. paper over each conductor and 5/32 in. over all, with 1/8 in. lead sheath. The feeders are connected to the high tension bus in groups of two, that is, there are two 500 ampere oil switches on each group, acting as selectors to throw the group on either bus.

The selector switches connect to a common point, to which two 300 ampere switches are connected, one for each feeder of the group. The purpose of this arrangement was not to effect a grouping of the feeders, as that in itself has certain disadvantages, but it carried out one of our principles of design, which is to always have two oil switches in series on every connection to the bus, and still permit a selection of buses without the use of open air hook type switches. We consider the hook type switch, when used as a selector, unsafe for large systems, even when interlocked; as this does not prevent their being opened by mistake and when opened while under load, with possibilities of se-

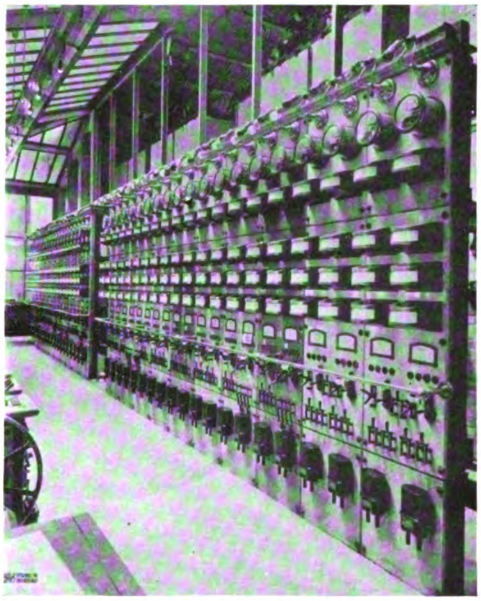

Fig. 5. High Tension Central Panels

vere trouble. There is a total of forty feeders in Waterside No. 1. Each feeder is equipped with an inverse-time-element overload relay, adjusted to open in 12 seconds with a load of 500 amperes, and in two seconds with a load of 800 amperes.

The normal feeder load is 200 amperes. The group switches have no provision for automatic opening.

The method employed by the New York Edison Company of connecting the relay and other auxiliary apparatus in the control circuit of the main feeder switches, differs somewhat from general practice. Experience has shown that a short circuit on a high tension feeder is usually capable of causing a severe depression of the bus voltage, and if it persists for more than one or two seconds, the converters will generally fall out of step. Therefore, if a feeder fails to open automatically and almost instantly, (depending on the extent of the short circuit,) the operator cannot be expected to detect the feeder in trouble and open it by hand within the time necessary to prevent general disturbance.

In order to provide the maximum reliability in the relay and oil switch control circuit, or in other words, to insure the prompt detection of an open control circuit, the wiring is so arranged that the bulls-eye indicating lamps perform the double function of indicating the position of the switch, and the continuity of the relay and switch operating circuits. If the indicating lamp burns normally, the operator has a positive indication that the whole relay and control circuit, including the armature, fields, and clutch of the oil switch operating motor, is in perfect condition. On the A. C. side of the relay, an ammeter is in circuit with the current transformer and relay coil, indicating, if at zero on a loaded feeder, that the relay circuit may be open. While this arrangement of the control may make it more complicated and require additional control wires, the large number of faults that it has detected in practice in time to prevent more serious trouble, fully justifies its use.

Among other precautionary measures, but of a less specific character, is a patrol every two hours, night and day; for the examination of the whole electrical equipment and switching galleries. During the time of peak load, however, this inspection is made every hour. Quite a number of incipient troubles have been discovered by this method, and the moral effect on the operating force of the assurance that the apparatus under their remote control is in satisfactory condition, is of positive value.

References might also be made here to the weekly insulation measurement of all generators and feeders. The readings are carefully tabulated, and any marked change, say, approaching 25%, is thoroughly investigated; with the usual result that any real trouble that may be developing, is located and remedied before a complete break-down of the insulation has taken place. An extreme puncture test is never applied to the feeders.

If a feeder opens automatically for any reason, and the cause is not apparent, an insulation test is first made; and if this proves satisfactory, as is often the case even on a defective feeder, a test voltage of 7500 volts is applied between each conductor and ground, and if this also proves satisfactory, the feeder is again put into service. All tests, however, failed to locate the trouble in a case where a short circuit had blown off the lead sleeve of a joint, and so effectively expelled the carbonized insulation from two of the three conductors that were left exposed, that the feeder, after the regular tests, was again put into service for some hours before the location of the trouble was reported because of a missing manhole cover.

Whenever a feeder switch opens automatically, which is only by overload, it is first thoroughly examined, the oil being removed from the pots for the examination of the contacts, new oil substituted, and the switch operated on open circuit before it is again put into service. The old oil is never used again for switch work.

In addition to this occasional cleaning that some of the switches receive, every switch is once a year completely disassembled, thoroughly overhauled and cleaned, reassembled with new oil, and carefully alligned.

To be continued.

MINING LOCOMOTIVES IN COAL MINES

By C. W. Larson*

The General Electric Company's mine locomotives are now in every respect standardized pieces of apparatus, and are well known in regard to design and reliability in operation, not only by all of our District Offices, but by all principal mine operators as well.

Figure 1 shows stand on which mine and industrial locomotives are tested. This affords every convenience and is a great time saver. Before this was erected it was necessary to respike tracks for all the different gauges, and it generally gave employment to two or more men every day, while this stand can be changed for any gauge and wheel-base in a few minutes time.

The first electric locomotive for mine haulage was put in operation in 1887, and from that time up to the year of 1900, the progress of utilizing electric power for mine haulage was rather slow. In the latter year the General Electric Company had less than 300 mine locomotives in operation, while at the present date there are over 1400 of the General Electric Company's make in coal, iron and copper mines. The same ratio will also apply to other electrically operated mine apparatus; such as pumps, hoists, etc. This relatively slow progress was due to different causes:

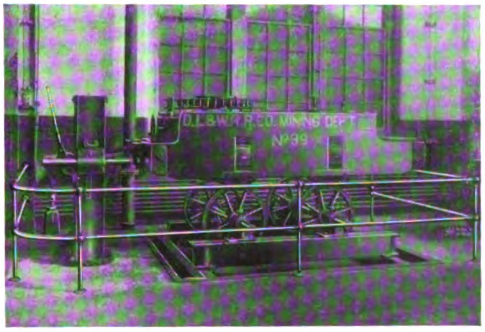

Fig. 1. **Testing Stand**

First, the steam and air locomotive makers fought strongly against electric installations, and succeeded in making the mine operators believe that it would be much more expensive to run electric power plants; besides which electric power was considered more or less dangerous, especially to mules and horses, as they frequently came in contact with the trolley lines, and almost every time this happened they were instantly killed. Since it seemed impossible to dispense with mules and horses for hauling cars to and from the workings, it was argued that they might as well be used for the main haul.

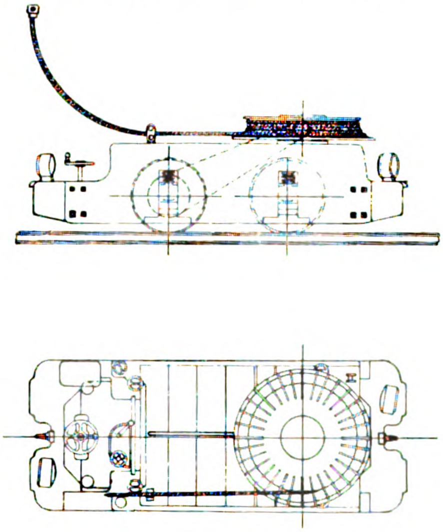

Fig. 2. Cable Reel Device on Locomotive

To improve on this unsatisfactory condition, certain manufacturers introduced small battery locomotives which were intended to haul the cars from the main headings to working faces of the rooms. These locomotives did not, however, prove a success. The batteries necessary for the power required made them entirely too large and heavy, besides which the batteries were smashed so frequently that it became a matter of entirely too high expense. The General Electric Company were frequently asked to design battery locomotives for this purpose, and did so, but the price came too high. In addition the Company's policy was not to encourage this apparatus, as it was argued that it would never become a success.

In the meanwhile, the author was quietly working on a design of a machine which it was thought could be successfully substituted for mules and horses, and in 1902 the so called "Cable Reel" device was introduced. Figure 2 shows its application. This first device was put in operation at Cayuga Mine, D. L. & W. R. R. Co., and mounted on a 6½ ton locomotive. The apparatus showed its value from the very start, and within a short time the General Electric Company received orders for a number of these locomotives, not only from the D. L. & W. R. R. Co., but from many other companies. It is indeed stated by customers that, if mine conditions are right, one of these locomotives will do the work that was previously done by ten or more mules. At the Cayuga Mine of the Lackawanna Railroad Company, one of these locomotives has easily tended 21 working chambers, gathering 130 loaded cars and replacing 130 empty cars per shift of 8 hours. At last accounts this locomotive was also working nights, handling the same number of cars, thus displacing 13 mules with their drivers on each shift.

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*Read before Local Branch A. I. E. E.

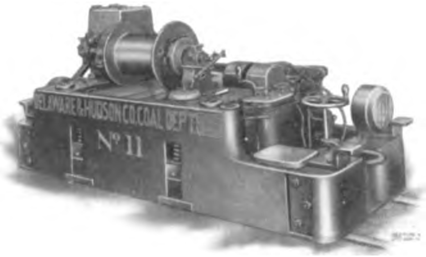

Fig. 3. Locomotive Hoist

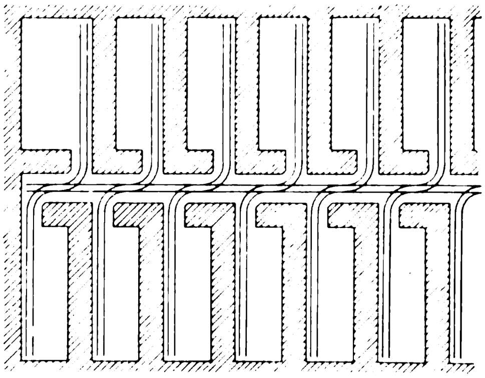

Fig. 4
Section of Portion of a Mine Showing Method of Excavation

Over 300 of these cable reel locomotives are now in operation, and assuming that each locomotive does the work of 10 mules, 3000 mules with their drivers are thus replaced by 300 locomotives and 300 motormen. The great saving effected by this apparatus can readily be appreciated.

Figure 3 shows what would be properly termed a "Locomotive Hoist", and was built for the Delaware & Hudson R. R. Company. This locomotive and hoist has been in operation about a year and has given gratifying results; another one of bigger size has now been ordered by the same company. It is used to hoist or lower empty or loaded cars to and from working faces, on grades up to 20% or more. The locomotive itself runs on practically level track, and the rooms are dug on a slope, on one side of main road down grade, and the other side up grade.

The locomotive is of standard design, and the hoist drum is placed on top of locomotive and operated by a separate motor; the controller and resistance, however, are the same as used for locomotive. The connection from locomotive to hoist, or vice versa, is made by throwing a switch connecting one circuit or the other.

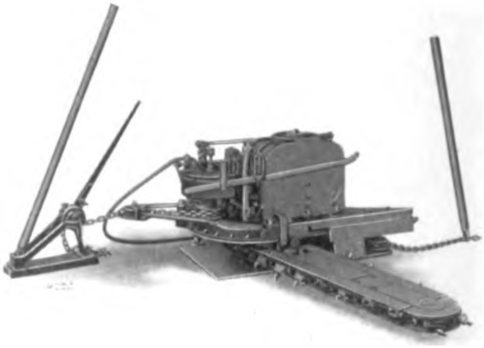

Fig. 5. Sullivan Coal Cutter

Figure 4 illustrates a small section of a mine and shows the regular method employed in coal mining. It represents the main heading running up in center, having turnouts to the rooms left and right; necessary side tracks, however, are not shown. The rooms vary in size, depending upon the solidity of the roof, and are from 20 up to 60 feet in width and from 40 to 300 feet in length. The thickness of the walls is generally the same as the width of room; in other words, about half the coal is cut out going in towards the limit of territory. After this is reached, the draw back mining begins. The walls are then cut out, one after another in succession on both sides of the main track. The roof thus loses its support and falls down and settles on the bottom of mine.

This illustration also makes clear how the cable reel locomotive is used. Before this machine was on the market, mules were used to pull cars in and out of the rooms, placing them on side tracks, and this, as previously explained, was a very expensive and inconvenient operation, since a great number of mules were required. The cable reel locomotive does the work with ease, each being able to take care of a big territory. Generally, the turn-outs are arranged on both sides of main track, curving in one direction. In this case, however, the turn-outs are curving opposite each other; this makes it necessary to have the cable reel device reversible, in order to take care of both sides.

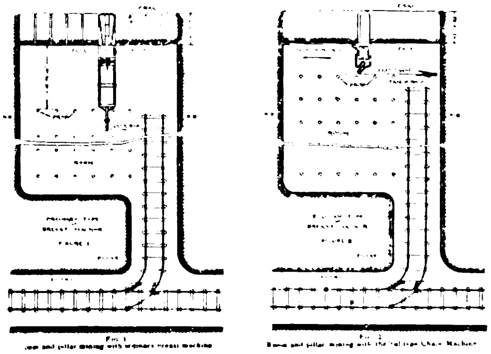

Fig. 6. Section of Rooms in Mine

Showing Relative Methods of Operation with Breast Machine, and Sullivan Machine Respectively.

In all mines from 25 up to 100% of bad coal, or so called "bone" or lignite is left. This class of coal substance is not now considered of any value, but the time will come when the conditions shall have changed and this scrap coal will become of great value, and thus the mines once considered emptied of their contents will again be dug out in search of remaining material, be it good or bad. I shall explain further on why this occurrence may take place.

Coal mining is still done to a great extent by the ordinary hand pick, while a good many, and especially bigger concerns, have adopted machinery of one kind or another.

Figure 5 shows the Sullivan Machinery Company's coal cutter. This coal cutter is different from any other make, in that it cuts across the room from one side to the other in one setting. This machine will cut at least twice the number of square feet per time unit as the ordinary breast machine. It is generally started at right hand side corner (see Fig. 6), and in the first operation it feeds itself in the total length of cutter bar, and after this point is reached, the machine is clutched over to the cross feed, and will then feed itself across the room, making an under-cut of 4 in. in height and from 4 to 6 ft. in depth. After this is done the machine feeds itself back and on to the truck, using its own motor power for propelling the truck, thus the operation continues from one room to the other. After this under-cut is made, a few holes are drilled, and the coal blasted out by dynamite.

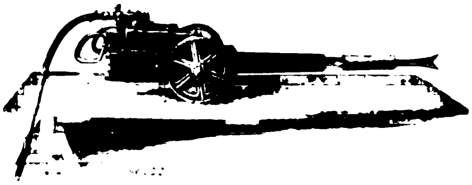

Fig. 7. Pneumatic Pick

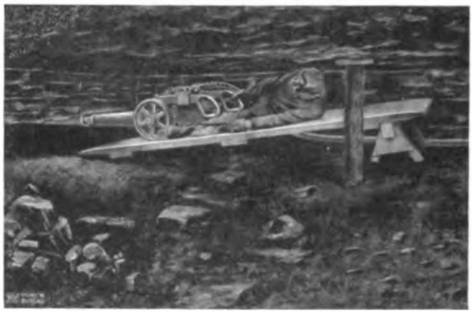

Fig. 8. Pneumatic Pick in Operation

Figure 6 shows two different rooms, one showing the method of Sullivan coal cutter, and the other the breast machine; the Sullivan cutter being fed in, and is in position to travel across the room; while the other shows outlines of the cut. From the cut you will note that this latter machine feeds in its cutter bar full length in the same way as the Sullivan machine in starting; then the bar is fed back, after which the whole machine must be moved over the distance of a cut and again anchored or braced, then started again and fed in, and so on. This is a very tedious and laborious operation.

There is also another great advantage using the Sullivan Coal Cutter. In mines having bad roof it is necessary that the props be located close up to working face, and the Sullivan coal cutter is especially well adapted for such conditions, as with its use the props can be placed within 4 ft. of the working face, while the ordinary breast machine requires from 10 to 15 ft. clearance, depending upon its total length.

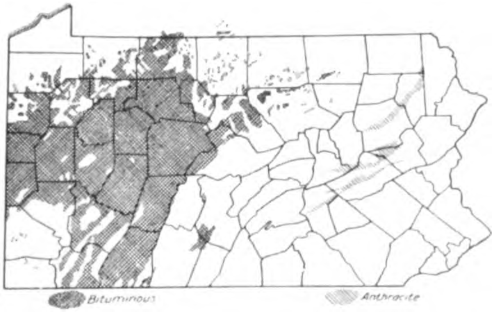

Fig. 9. Coal Map of Pennsylvania

Figure 7 shows the Sullivan Company's pneumatic pick machine, which works on the same principle as a regular rock drill, except that the piston moves in a horizontal plane and the stroke is much longer.

Figure 8 shows the Sullivan Company's pneumatic pick machine in operation. This machine is especially well adapted for low veins, where the coal vein runs irregularly. The illustration shows just such a place where there is not enough room for the operator to sit up, so that he must lie on his side.

Figure 9 is the Mineralogical Map of the State of Pennsylvania, the dark parts being coal deposits.

In the past coal has been mostly valued in accordance with its steam producing quality when used for firing power boilers, but recent tests and discoveries make it clear that coal which is poor for producing steam has been very incorrectly classed. Indeed, it is now proved that the poorer the coal is for steam production, the greater is its power value if used in connection with gas producer. Soft coal, or even lignite, when turned into gas and burned in power gas engines, will produce even more net horse-power per ton of fuel than the best anthracite coal. Bituminous coal when used for gas will produce from two to three times as much power as when used for firing boilers.

It is estimated that the expenditures for coal by the New England States manufacturers are $50,000,000 annually. If gas engines were used instead of steam engines, this sum would be reduced to approximately $30,000,000.

The United States Navy uses up about 700,000 tons of coal at the cost of approximately $3,500,000, and if gas engines were substituted, a saving of approximately $1,400,000 could be effected.

The United States spends about $1,600,000,000 annually for coal and other fuels. This figure could be reduced by $700,000,000 by a similar substitution, and the General Electric Company's Schenectady Plant would save approximately $150,000 annually if system as above explained was adopted.

At the time coal commences to get scarce, the gas producing quality of poorer classes of coal will be well established and, as before mentioned, the old closed up mines will then again be operated and cleaned out of their entire contents.

Of course I do not mean to say that this change in power engines will become general, but I do believe that before long there will be a great demand for gas engine power plants, and I think it is up to the present generation, and especially to the Engineering faculty, to devise such methods by which fuel could be saved. It is indeed predicted that the world's coal supply will determinate in about 300 years, the figures being based upon the present consumption, which is approximately eleven hundred million tons annually; and when considering the long time the earth will have to exist, one almost feels that the end of the 300 years is here. It is stated by our scientists that the sun system and earth will keep on uninterrupted without noticeable change for at least one thousand billion years to come.

RECENT DEVELOPMENTS IN ARC LIGHTING

By R. FLEMMING*

The electric arc, as applied to illuminating purposes, has, until recently, been confined almost entirely to an arc drawn between electrodes of carbon, the energy being utilized in (a), heating the electrode in proximity to the arc, and in (b), heating the stream of carbon vapor between the electrode points. A small portion of the surface of each electrode is thus raised to a temperature at which the carbon becomes incandescent, the luminous flux being derived almost wholly from these incandescent surfaces, while the energy in the arc stream proper is wasted; carbon vapor at a high temperature being non-luminous, or nearly so, and what little light comes from this source being at the violet end of the spectrum and beyond. The characteristic color of the carbon arc, especially when viewed horizontally, is due to this radiation from the arc stream. When direct current is supplied to the arc, the anode becomes more highly incandescent than the cathode, or rather, a larger anode surface becomes incandescent. The cathode is incandescent only to a comparatively limited extent. This phenomenon is not well understood. In the alternating arc, the electrodes are, of course, alternately anode and cathode, and both are about equally luminous.

To the fact that the carbon arc is luminous, by virtue of the incandescence of its electrodes, is due its limitations. Immediately beneath the incandescent surface, the mass of carbon has a relatively low temperature, hence a great loss of heat by conduction. The electrode, too, has considerable surface from which heat is radiated. This surface is constantly washed by ascending currents of cold air, which further aids in the dissipation of heat. These air currents also have the effect of oxidizing the carbon and rapidly wasting it away so that in the case of the open arc, the electrode has to be much larger than would otherwise be necessary, and even then has a very short life.

To overcome this latter defect, the expedient of the enclosed arc has been resorted to. This had the desired effect of preventing too rapid oxidation of the electrodes, but had the disadvantage of decreasing the efficiency of the arc in that the electrodes burned to a flat end instead of a point as before. This caused increased conduction of heat from the incandescent crater, due to the mass of carbon immediately surrounding it.

The enclosed arc is further handicapped by the absorption of light by the enclosing globe, and by the shadows of the electrode tips. Nevertheless, the enclosed arc is today an eminently practical device, and is especially well adapted to interior illumination when properly installed and cared for, and supplied with current at reasonably uniform potential.

The carbon arc, depending on the incandescence of the electrodes, has probably reached the limit of development, and there being apparently no element, or compound of elements, that can satisfactorily be made incandescent at a higher temperature, attention has been turned toward introducing luminous vapors into the arc. If the vapor composing the arc stream between carbon electrodes gave off a luminous radiation within the useful part of the spectrum, carbon would have been an ideal, and much more useful material for the purpose. The products of combustion are entirely gaseous and practically harmless and inert, as we know from experience with the large number of lamps that have been used for interior illumination.

The attempt has been made to supply the deficiency of luminous radiation from the arc proper by introducing into the carbon arc, vapors derived from the salts of various metals, the salts of calcium being largely used for the purpose. The light is nearly monochromatic, being largely in the yellow portion of the spectrum, hence as an illuminant is very efficient, due to the physiological effect on the eye, and is satisfactory for the illumination of open spaces when little attention need be paid to color values, and where a large unit of light is not a serious disadvantage.

Technically, these electrodes are known as "flame" or "effect" carbons. They consist of carbon of a high grade of purity having a core filled with the desired salt, or combination of salts. In some cases there is a mere tubular shell of carbon filled with a mixture of these salts and carbon.

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*Read before the Local Branch A. I. E. E.

The arc between a pair of these electrodes is very different from the normal carbon arc. The arc stream is a veritable flame of an elongated inverted cone shape, having its apex at the point where the arc springs from the lower electrode and its base surrounding the tip of the upper electrode. This arc, or flame, has a brilliantly luminous core of nearly uniform cross section extending between the electrodes. This luminous core is the true arc stream, and consists of the decomposed vapors of carbon and of the materials of which the electrodes are composed. Immediately surrounding this core is a zone of combustion in which the metallic and carbon vapors are re-combining with the oxygen flourine, etc., of which they were originally composed, as well as with the oxygen of the atmosphere. Surrounding this again is a semi-opaque envelope composed of the products of combustion, which have now reached the condition of smoke.

I have assumed here that there is an actual dissociation of the different salts of which the electrode is composed. This is a point that is somewhat open to discussion, as it is not universally conceded that dissociation actually does take place. It is reasonable to suppose, however, that in the extremely chemically active atmosphere of the arc, the oxides would be, at least, partially reduced by the carbon vapor at such an extremely high temperature, forming CO and CO_2 and either metallic calcium, or calcium carbide vapor. These calcium vapors, upon reaching the outer limits of the arc, will be oxidized by the air, and thus produce the calcium spectrum which is characteristic of the arc. I will not here enter into any discussion of ionization in the arc.

Thus far, I have assumed that carbons are arranged vertically. European engineers persistently use the converging carbon type of lamp, with the arc playing between the lower tips, and sometimes repelled by an electro-magnet placed above the arc. A cup-shaped reflector or "economizer" is generally placed above the arc for the double purpose of reflection and pocketing a quantity of inert gas around the electrode tip to minimize oxidation of the carbon. This type of lamp requires a carbon of very small diameter, to assure that the arc will always play from the tip end, it being necessary that the arc be constantly supplied with the volatilized luminous vapor from the core. It is necessary that the carbons be of great length to obtain anything like reasonable life per trim, and even then a life of only 15 or 16 hours is obtainable as a maximum.

In nearly all the flame carbon lamps now in use, little or no provision is made for the disposal of smoke, or fume, the result being that condensation takes place on the surface of the glass globe, obscuring the light. A very large absorption of this monochromatic light takes place in the glass itself. Measurement shows an absorption greater than 50 per cent in some cases at least, the absorption increasing very markedly with the opalescence of the glass; with good clear glass, the absorption seems to be moderate, but the light intensity is too great for use in this way.

In Europe, these "flame" or "effect" arcs have made some headway, largely because rates for current supply are high, and the prices for carbons and labor very low. When these conditions become reversed, as they are in this country, the advantage is not so great.

It is characteristic of the carbon arc that the arc stream proper is non-luminous, while the electrode tips are luminous by virtue of their incandescence. The reverse is true of the metallic arcs, here the electrodes are dark, or nearly so, the entire luminosity being derived from the vapor in the arc stream between the electrodes. These vapors, by which the arc is sustained, are derived entirely from the negative electrode or cathode, by its disintegration at the point of contact with the arc. Here the metallic salts are decomposed, and a stream of their constituent vapors is projected against the anode, thus forming a conducting path of comparatively low resistance.

The temperature co-efficient of this resistance is negative, hence the current tends to flow through the hottest part which, of course, is the center. The current follows the intensely heated core of the flame, thus maintaining its temperature, and consequently its luminosity. The higher the negative temperature co-efficient, the more thread-like, and generally the more luminous will the core of the arc become; this temperature co-efficient varies considerably with the different metals and their salts. For the alkaline earth metals, it is low, hence the large flame-like appearance of the arc. For iron, it is also moderately low, but for other metals the co-efficient is very high, hence the arc stream is extremely thin and intensely luminous, with a beautifully white light well distributed in the spectrum. The light from such an arc is undoubtedly the nearest approach to daylight that artificial means can produce. The alkali metal arcs produce a strong light almost wholly in the red and yellow end of the spectrum. Visually, this is a powerful light, but totally unsuited for general illumination.

The iron arc produces a bluish white light of fair intensity. Iron, and in fact all metals, are unsuitable for use as electrodes in the metallic state. Their oxides and other salts being much better adapted for the purpose. Iron is almost unique in that one of its oxides is a conductor at normal temperatures. This property has made the black oxide ($Fe_3 O_4$) known as magnetite, a very important factor in the development of the art of illumination. When used alone, this material produces, as stated before, a light of good intensity, but is susceptible of very great improvement by the admixture of the oxides and other salts of various metals. By using magnetite as a base, or carrier, various materials can be added that will greatly increase the efficiency, and the quality of the light, as well as its steadiness, and at the present time these qualities are everything that could be desired. Furthermore, other materials can be added that will increase the useful burning life of the electrode many times its natural span so that a commercial trimming of 175 hours is now the general practice. Colored effects can also be readily produced if considered necessary, but to contaminate a pure white light would be more useless than painting a lily.

The commercial magnetite electrodes consist of thin iron tubes 8 in. long by ⅝ in. diameter, into which is closely packed the powdered mixture of magnetite and other salts. The end of the electrode clamped in the holder is closed by a wooden or metal plug while the burning end is sealed by a thin metal disc over which is crimped, cartridge fashion, the end of the tubular shell. This thin disc is burned away in the arc in a very few minutes; the arc then assumes its normal condition.

The adoption of the metallic arc has naturally necessitated the construction of special lamps in which to burn the electrodes successfully. In the design of these lamps, several important requirements had to be kept constantly in mind. The products of combustion in the arc are all solid metallic oxides and are thrown off in the form of fumes or smoke, consisting of extremely minute particles. This material readily floats in the air, and in this manner a portion is carried off into the atmosphere. A large amount, however, condenses or settles on the upper electrode and metallic parts of the lamp over which they pass, and it is necessary in the design of the lamp to arrange that this material does not interfere with the proper operation of the arc.

Disposal of the fumes is effected by means of a chimney or draft tube passing upwards through the center of the lamp and open to the atmosphere at the top, in such a manner that the slight circulation of air necessary is not interfered with in the least, even by the heaviest wind storm. In fact, the whole lamp is constructed with a view to preventing interference by wind currents, and the desired result has been gained.

Owing to the fusion of the cathode at the point from which the arc springs, if the electrodes are allowed to come together on shutting off the current, they will weld fast, and cannot be separated by the mechanism when the current is turned on, once they have cooled. This made it necessary to maintain the electrodes separate at all times, except momentarily when the arc is being struck.

Electrically, the lamp is also quite different from the usual type of carbon lamp, especially in that the arc is in no way controlled by the magnets during operation. The main coils are out of circuit entirely, and only a small cutout coil is energized by the main current. A second cutout coil is connected in shunt with the arc, and operates when the arc voltage reaches a predetermined value, and as the electrode is consumed at a very slow rate, this coil comes into action only after several hours' burning. The arc is then short circuited, the main coils energized momentarily, and the arc is readjusted anew to its normal length.

The upper electrode, or anode, has been referred to as non-consuming. This is an important feature of the lamp, and has much to do with its low cost of maintenance. It is composed of copper, and the type of anode now used will probably last several thousand hours. Measurements show, at least, that after about 5000 hours' burning, the wear is almost inappreciable.

Owing to the fact that the arc is maintained in a fixed position, it was found an easy matter to locate a reflector in such a manner as to be most advantageous. A flat reector of porcelain enameled steel is placed just above the plane of the arc, and the reflected light is thrown out at an angle of 10 to 20 degrees below the horizontal, just the angle most useful for street illumination. For interior work, a reflector can be used that will project the light in a downward direction as much as may be desired.

The luminous arc magnetite lamp as now perfected, has so far been used entirely for street lighting, and for this work has proven a very gratifying success. Several large installations are in regular operation, and the number of such installations is constantly increasing.

Up to the present time, this system of lighting has only been used for street work, the lamps being operated in series from arc generators, or from constant current transformers with mercury rectifiers.

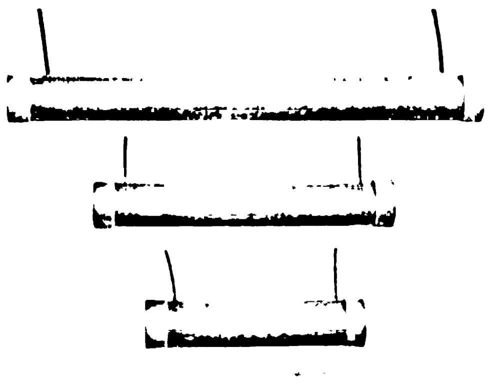
Developmental work has been completed, and designs are now ready for lamps to operate in multiple on 110 and 220 volt constant potential circuits. These lamps will be very useful in a great many locations where enclosed multiple arcs are now used, such as store front and yard lighting, and for all interior work, except in such locations as dry-goods stores, where the fumes thrown off may do some damage to stock or to decorated ceilings.

THE NEW RESISTANCE UNITS

By C. D. KNIGHT

The various forms of resistance coils that have heretofore been on the market, have possessed certain inherent characteristics that have rendered them fragile and liable to breakage in handling and shipment, and destructible when in service. In the new resistance coils manufactured by the General Electric Company the defects that have existed in the former varieties have been eliminated, and a coil produced which is both strong and durable.

The feature that makes both of the other principal types essentially breakable is the porcelain tube upon which the wire is wound. This difficulty has been met in the new units by the use of a reinforced asbestos tube instead of porcelain.



Form P Resistance Coils

Another fruitful source of trouble lies in the means used for protecting and holding the wires in place.

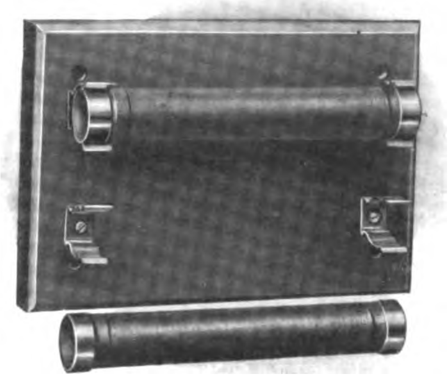
One method has been to surround the wire with a perforated iron shell through which cement is forced until the space within is filled. Experience, however, has shown that upon drying out, this cement draws away from the shell, leaving a layer of air which, being a poor conductor of heat, tends to reduce the radiating capacity of the unit by concentrating the heat within. In addition to this difficulty the cement frequently cracks when heated, thus affording an unobstructed passage for an arc to form a short circuit on the iron shell, in event of a burn-out.

When enamel is used instead of cement trouble arises through its melting when overheated. The units being mounted in a vertical position, the composition runs down and the convolutions of resistance wire tend to slip down and together; for being expanded by heat, they no longer cling to the tube; and the enamel having been melted out, there is nothing to hold them in place. The result of this is, of course, a material reduction in resistance and a dangerous rise in current, which destroys the unit.

As stated, the new General Electric unit is wound on an asbestos tube, which has the advantage of not being fragile like porcelain. The wire being wound under tension embeds itself in the asbestos, thereby forming a positive mechanical separation of the successive convolutions. After winding, the tube is dipped in a special compound, which forms a coating both inside and out, reinforcing the asbestos and making a very strong and solid construction. Porcelain or metal bushings are then inserted in each end of the tube, the coating compound cementing these in place. The unit is then thoroughly baked, and when completed will withstand very rough usage. Unlike some forms of cement, the coating compound will not crack, nor will it melt or run like enamel, but on the contrary becomes harder when subjected to high temperatures.

When purposely submitted to very excessive current for experimental purposes, the wire could only be burnt out in one small point, the resulting arc being quickly and quietly extinguished.

The units can be wound for any resistance from ¼ ohm to 10,000 ohms, and are to be made in three standard lengths, viz., 5½ in., 7½ in. and 11½ in., the diameter being 1 in. in each case. These tubes are made up in three different ways: Form P with porcelain ends, to be mounted without other insulation on iron rods, or such other suitable projection as will fit into the recess of the porcelain bushing.


Form PM Resistance Coils

Form PM with metal ends that can be inserted directly into standard fuse clips, making the unit very accessible for replacement. The third type consists of the usual form of tube, but mounted on a specially arranged screw plug, so that the unit can be screwed into an ordinary lamp socket for switchboard practice.

These units have been approved by the United States Navy Dept. for use in their rheostats and controlling outfits.

LARGE CURTIS TURBINES IN CHICAGO

By W. L. R. EMMET

Engineer of General Electric Company's Lighting Department

In the plant of the Commonwealth Electric Co. at Fisk St., Chicago, eight large Curtis turbines are now in operation. The four last installed have a nominal rating of 8000 Kw each, and are representative of the most advanced development. The first of these machines have been in operation for several months, and all of them are showing phenominal results. They operate daily for long periods with loads as high as 12000 Kw. On several occasions a single machine has carried 14000 Kw under conditions which show a very low steam consumption. Only eight 500 HP B. & W. boilers are installed with each machine; these boilers being fired with Illinois coal, having about 10000 heat units per pound. One machine has carried 13000 Kw with seven boilers fired. Owing to the continued heavy loads which these machines have been called upon to carry, it has been up to the present time impossible to make steam economy tests. We can however estimate the steam consumption from the known nozzle area and initial steam pressure. This estimate indicates a steam consumption below 13 lbs. per kilowatt hour output, with 185 lbs. boiler pressure, 150° superheat and a 27½" vacuum. The coal consumption on these units is averaging about 2.7 lbs. per kilowatt hour, and this with the low grade coal used indicates a performance as good as the estimate above mentioned. These machines are almost entirely noiseless, and carry the extreme loads above mentioned without any objectionable heating.

The turbines used with these units have five stages with two rows of moving blades in each stage. With a load of 10000 Kw, the work is about equally divided between the stages. The turbines are mounted on condenser bases designed by the General Electric Co., and these condensers have shown particularly fine results. Each condenser is provided with 25000 sq. ft. of cooling surface, and the pumps are designed to circulate about 18000 gal. of water per min. A vacuum of 29" has been carried with a load of 12000 Kw.

The generators used with these machines are of a new design, and embody many interesting advantages. The revolving field is so arranged as to act as a very effective air impeller, which forces ventilating air through all parts of the machine which require it. The outside of armature frame is a solid cylinder, the arrangement being such that the ventilating air enters at one end of the machine and passes out at the other. This arrangement entirely deadens all noise produced by ventilation, and the machines in operation are almost entirely silent. This absence of noise is of great practical advantage in any station. That it is accomplished without impairment of ventilation is shown by the very heavy loads which these machines carry without objectionable heating.

MULTIPLE UNIT CONTROL OF D. C. MOTORS

By G. H. Hill

Part II

The desirability of accuracy in this respect has led to the following method of determination of resistance steps. While the specific development is for series parallel control of series motors on a railway car, the same is obviously applicable to any rheostatic acceleration of series motors. The average accelerating current in the case of a railway motor is determined from considerations of schedule,—speed, economy of power, and capacity of motors. This being given, the maximum current value, and consequently the current fluctuation per acceleration step, is determined from consideration of either the practicable coefficient of rail friction, or the question of comfort to passengers, mechanical strain to couplers, etc.

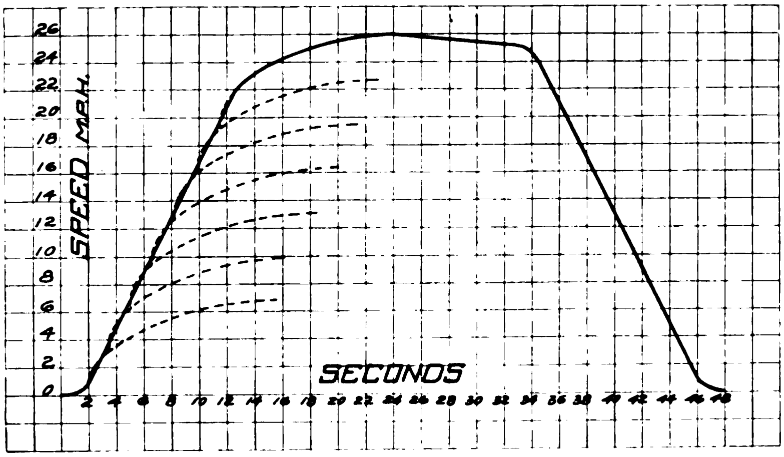


Fig. 11. Representative Speed-Time Curve

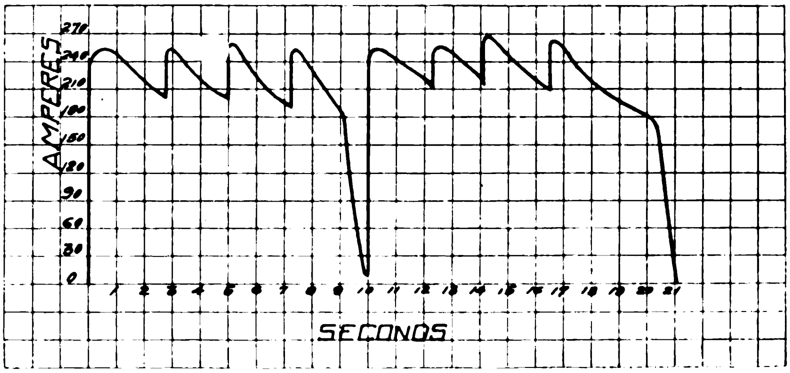


Fig. 12. Current Record of Acceleration with Open Circuit Type of Control

A "comfortable" acceleration is of much importance in passenger service. This is a function, not of the average acceleration rate, but of the rate of change of acceleration, that is, the second differential of speed. An acceleration of 2 M.P.Hr. per sec. may be just as comfortable as one of 1 M.P.Hr., provided it is attained not too quickly, and maintained without too sudden or extreme changes from the average rate. It is a question of current change per motor on any specific equipment, but more properly should be considered with reference to the difference between the acceleration rate at the minimum and maximum current values respectively. The change in acceleration rate at the first application and at the cessation of driving power must also be considered. While it is usual in plotting speed time curves to represent the acceleration as a straight line (see full line, Fig. 11), it is really made up of increments of motor curves at different voltages as shown in dotted lines. The angle that these incremental motor curves make with each other is a measure of the change in rate of acceleration and therefore of the comfort. The retardation curve is just as important for comfort as the acceleration. The point at which current is shut off during acceleration may be very pronounced if the train friction is high, as when a motor car is drawing trailers, or when climbing a grade.

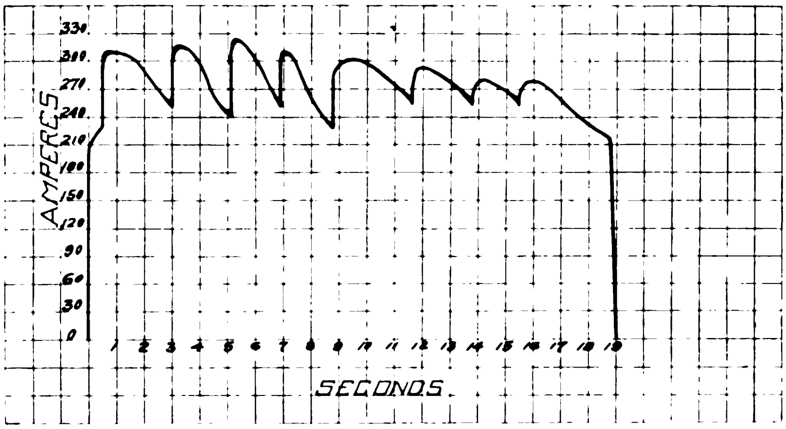


Fig. 13. Current Record of Acceleration with the Bridge Type of Control: Equal Steps Series and Parallel

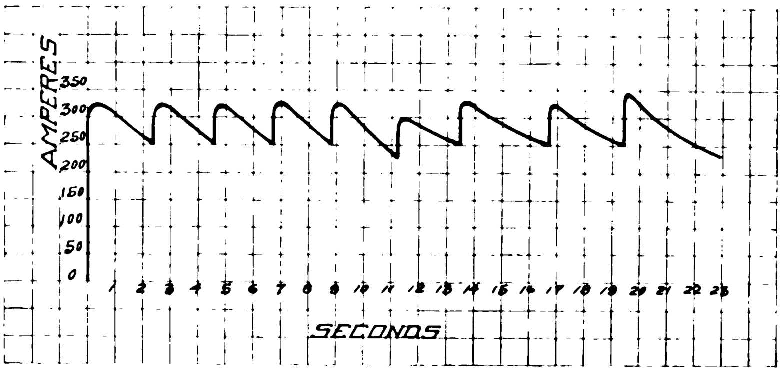


Fig. 14. Current Record of Acceleration with Bridge Control: Five Steps Series and Four Steps Parallel

The effects of poorly adjusted brakes or improper handling of brakes need no comment. Here again it is the angle which the braking curve makes with motor or coasting curve, or with the base line, i. e., zero speed line, that determines the comfort. The reduced coefficient of friction between the brake shoes and the wheels at high speeds, serves to a considerable extent to blend the braking curve with the coasting or motor curve without a sharp angle, and a very steep braking curve will be entirely comfortable if the brakes are partially released just before stopping, so as to round off the curve into the base line.

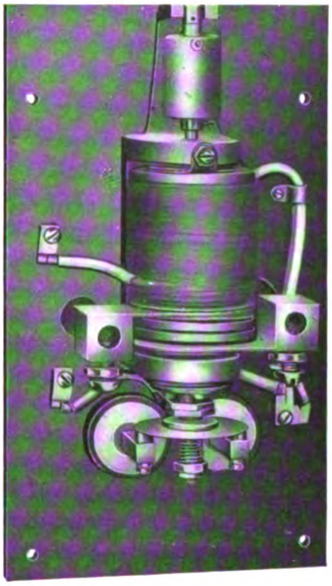


Fig. 15. Relay for Automatic Control

The value of maximum current in acceleration is usually 10 to 12½% higher than the average.

With the maximum 10% above the average, the maximum will be 22% above the minimum to give equal fluctuations above and below the average value.

Let C' = the maximum current per motor during acceleration.

C'' = the minimum.

C = the ratio $\frac{C'}{C''}$.

V = line voltage.

S' = the speed of the motor at line volts and C' amperes.

S'' = the speed of the motor at line volts and C'' amperes.

S = the ratio $\frac{S'}{S''}$.

r = resistance of motor at average heat, say 75° C.

R' = one external resistance value per motor.

R'' = the succeeding smaller resistance value.

(1) Then $V - C''R' - C''r$ = counter e. m.f. of one motor at the minimum current value, with R' external resistance when motors are in multiple relation;

(2) and $V - C'R'' - C'r$ = c.e.m.f. at the maximum current value and R'' resistance.

It is evident that in advancing one acceleration step the c.e.m.f. of the motor changes without increasing its speed from value (1) to (2), and as the speed then increases the current falls from C' to C'', and then another change is made in resistance such that the current is again increased to C', and so on until all resistance is cut out.

It may be shown that values (1) and (2) bear the same ratio as S' to S'', viz.:

$$(3) \quad \frac{V-C''R'-C''r}{V-C'R''-C'r} = \frac{S'}{S''}.$$

This relation is evident from the consideration that the increased c.e.m.f. when the current is instantly increased, (i.e., without speed change) is due entirely to the increased flux through the armature, produced by the increased current in the motor, and that the speed change at a constant voltage, between the same values of current, is a measure of this change in flux and consequent change in c.e.m.f.

Solving (3) for R' and writing S for $\frac{S'}{S''}$ and

C for $\frac{C'}{C''}$

$$(4) \quad R' = SCR'' + \frac{V}{C''}(1-S) + r(SC-1).$$

If now we let R' be the last resistance step, then $R'' = O$

$$(5) \quad \text{and } R' = \frac{V}{C''}(1-S)+r(SC-1)$$

which immediately gives the last resistance step for one motor.

Then letting R′ be the next higher resistance step, its value is given by (4) and so on for each successive step, repeating the operation until the proper resistance value for the first multiple step is reached.

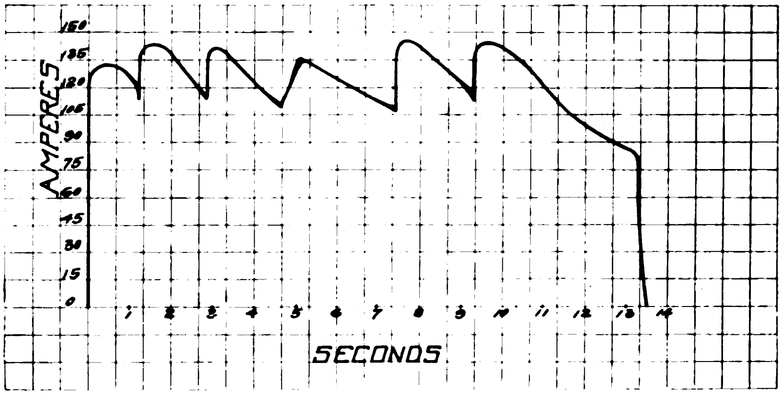


Fig. 16. Current Record of Acceleration with Automatic Control Car on Level Track

This first multiple step is given by equation

$$R = \frac{V}{C'}\left(1 - \frac{1}{2S}\right) - r\left(1 - \frac{1}{CS}\right).$$

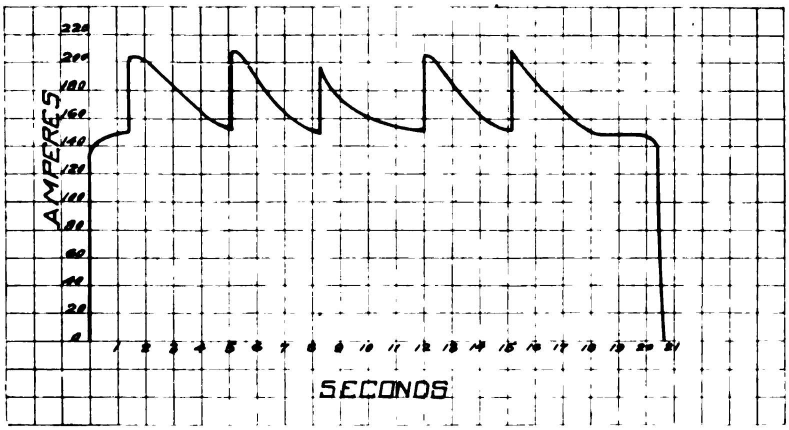


Fig. 17. Current Record of Acceleration with Automatic Control Car on 5% Grade

The last term of this equation is very small and may be omitted, giving

$$(6)\quad R = \frac{V}{C'}\left(1 - \frac{1}{2S}\right).$$

This equation is obtained as follows:

In full series at C″ current, c.e.m.f. of motor $= \frac{V}{2} - C''r.$

This value becomes $\frac{\frac{V}{2} - C''r}{S}$ when the current is instantly increased to C′. With this maximum current C′ and the motor across full voltage, V (i.e., first point parallel), the external resistance must be such that

$$V = \frac{\frac{V}{2} - C''r}{S} + C'R + C'r$$ which reduces to Eq. (6).

Where the method of control is such that the motors are open circuited in passing from series to multiple relation, this change from C″ to C′ current is not instantly made, since it first drops to zero value. As the inductive e.m.f. of the motor is considerable when the current increases rapidly from zero to C′, a reduction must be made in the value of R for the first multiple step to allow for this.

A similar inductive e.m.f. exists at each change of current from step to step, but its value is small for the change from C″ to C′ and may be neglected. Its effect will be to round off the peaks of the maximum current, so that a current record will show slightly lower maximums than calculated.

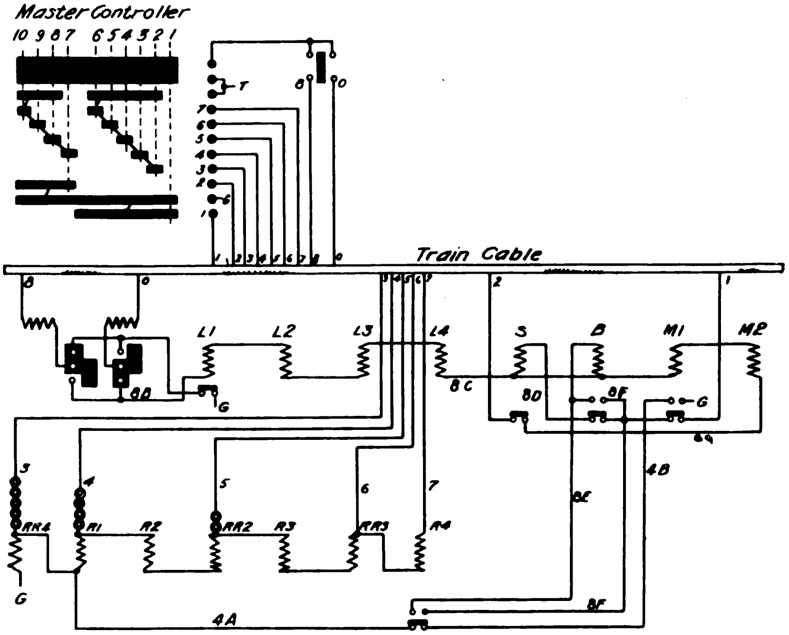


Fig. 18. Control Circuit of Sprague General Electric Hand Control

In the series relation, as each motor has half voltage, the value V becomes $\frac{V}{2}$ and equation (4) becomes—

$$(7)\quad R = SCR'' + \frac{V}{2C''}(1-S) + r(SC-1).$$

From this the values of the resistance steps per motor in series may be determined as above explained for parallel.

The first series accelerating step is given by

$$R = \frac{V}{2C'} - r.$$

All of the resistance values are per motor, and the values for series are therefore one-half the total resistance, and for parallel twice the total resistance for a two-motor equipment.

In addition to the accelerating steps, it is usual, as already mentioned, to have a low current or "switching" step for the first series position, giving a slow acceleration for use in coupling cars and affording a preliminary to full accelerating current during which the slack is taken out of the motor springs, trucks, couplers, etc.

The value of the switching step resistance is usually such as to give a tractive effort of from 100 to 150 lbs. per ton for the motor car alone, the value depending somewhat on the average rate of acceleration and local conditions. An allowance in the resistance value for inductive e.m.f. must also be made here.

In applying the foregoing formulae, it will be found that a greater number of resistance steps are required in series than in multiple for a given fluctuation of current.

When two-motor groupings only are used, the proportion of five steps series and four steps parallel is very nearly correct if the torque is continuous throughout as in the bridge control. When the open type control is used, the loss of torque and acceleration during the series parallel transfer, causes the current fluctuation in parallel to be about the same as in series with an equal number of steps.

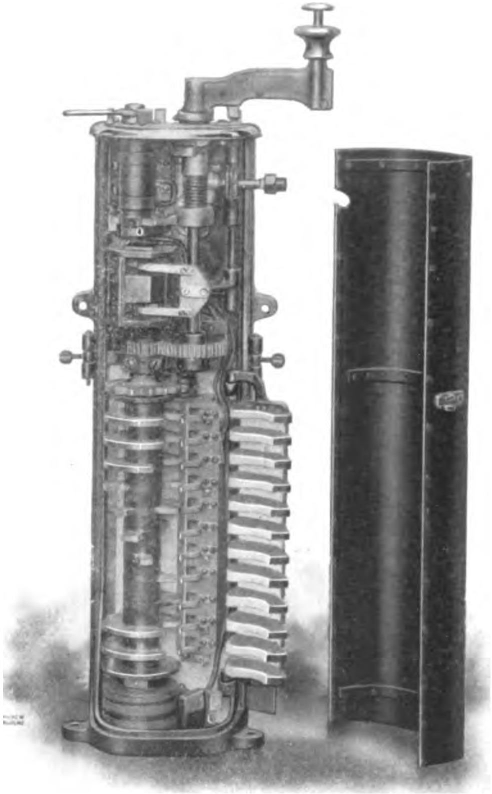


Fig. 19. Master Controller for General Electric Hand Control

Figure 12 is a current record, taken on a recording ammeter, of an acceleration with an open type of control having four steps series and parallel. The current fluctuations are seen to be practically the same in series and in parallel.

Figure 13 is a similar record with a bridge form of control and shows considerably less fluctuation in parallel than in series.

It is evident that this acceleration will not in most cases give the best results. If the motors are working close to the limit of traction, there is danger of slipping the wheels when connected in series, and the average rate of acceleration is limited by the series maximums.

Figure 14 is a current record with five steps series and four parallel, and gives practically identical fluctuations throughout.

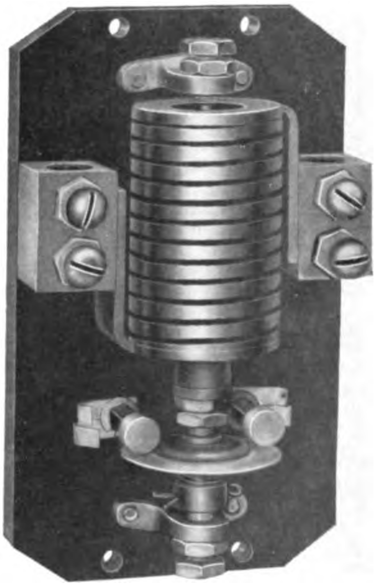


Fig. 21. Relay for Spring-Driven Controller System

Remembering that with an automatic control the minimum values of current are kept constant by the action of the relay, and that the limit of acceleration is determined by the maximum values, it is evident that only with a uniform variation, as in Figure 14, can the best results be obtained. An increase in the number of steps in series alone, or in parallel alone, will result in a decreased acceleration. By increasing the steps both in series and in parallel, in the proper ratio, the fluctuations may be reduced, with a gain in the possible average acceleration rate.

With the relay on an automatic control set for a definite current rate, which is naturally determined by the average conditions, the tractive effort during acceleration is, of course, limited to the amount corresponding to this current.

In many cases the full power of a motor equipment may be needed only for a particularly heavy grade in the line, or in emergencies such as disablement of other cars. To adjust the acceleration and current rate for the maximum conditions would in such cases overload the motors and give unnecessarily rapid acceleration for normal working.

This is overcome by introducing a time element into the control in addition to the current regulation. The relay, as shown in Figure 15, is provided with a small air dash pot which does not interfere with the upward movement of the plunger, but retards its downward motion. The current adjustment is set to give the maximum tractive effort desired for a given equipment. The dash pot may then be set to retard the relay and limit the acceleration to a given time. This time is made right for the average conditions, and the current for acceleration under these conditions will be well below the value for which the relay is set. When, however, the motors do not speed up promptly within the period of the relay time setting, as on a grade, or when pushing a disabled car, the current rises to the full value, and the current action on the relay controls the acceleration.

Figures 16 and 17 are current records of the same car and equipment taken on

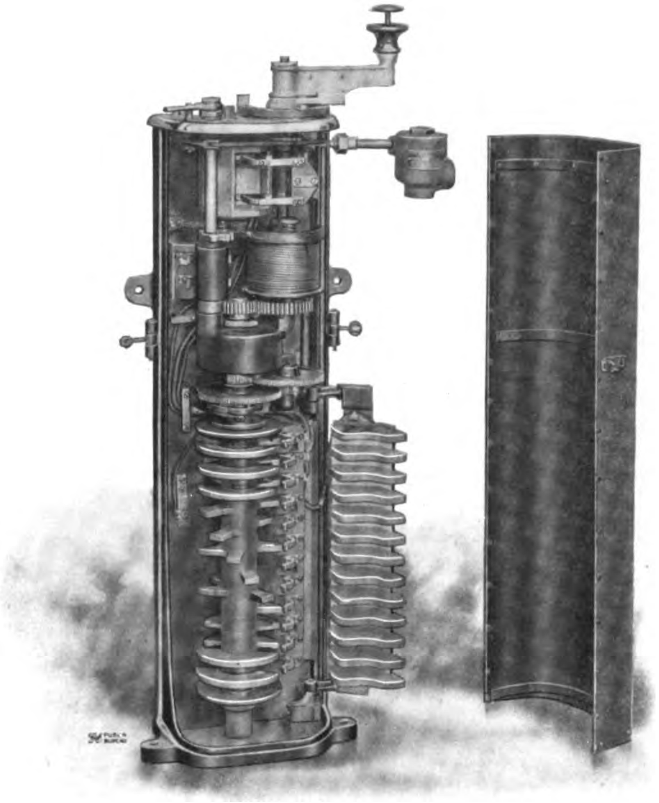


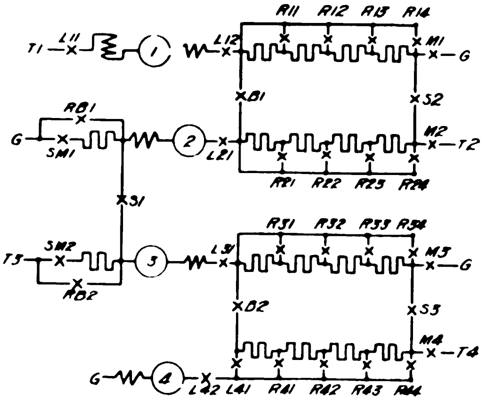
Fig. 20. Spring-Driven Automatic Master Controller for General Electric Control

the same run without any adjustment or changes, and show that on a level the input was about 70% of that on the grade.

In Figure 18 are shown the control circuits of a hand or non-automatic form of the Sprague General Electric control. The motor circuits are the same as for the automatic control, Figure 6, to which the lettering applies. The master controller, illustrated in Figure 19, has a definite position for each resistance step, and its several contact fingers are connected through the train line wires with the corresponding contactor coils. The master controller is moved from step to step by the operator as he desires, and the contactors follow the action directly. The results are precisely the same as if an ordinary platform controller were arranged with its main contacts located at a distance from the handle.

The circuits are so simple that it is hardly necessary to follow them through in detail. It will be noted that the circuit of the 8 (or O) wire after passing through the reverser and L coils, is in series through the S coil and wire 8D to No. 1. When the last resistance contactor, R4, is closed, coil B is energized through 8E and 8F to No. 1, and the S circuit is cut off. When contact is made at the master controller with No. 2 finger, the coils M1 and M2 are energized through 8G and wire 2, and the B circuit cut off.

In parallel, the RR4 coil is short-circuited by the 4A and 4B wires until the



Steps	Contactors Closed
1	L11-L12-S2-L21-S1-L31-S3-L41-L42
2	Same plus R24
3	″ ″ ″ R44
4	″ ″ ″ ″ R34
5	″ ″ ″ ″ ″ R11
6	″ ″ ″ ″ ″ ″ R12
7	″ ″ ″ ″ ″ ″ ″ R13
8	″ ″ ″ ″ ″ ″ ″ ″ R14
8½	Same as 1 plus - SM1 - SM2
9	L11-L12-S2-L21-RB1-RB2-L31-S3-L41-L42
10	Same plus R24
11	″ ″ ″ R44
12	″ ″ ″ ″ R34-R11
13	″ ″ ″ ″ ″ ″ R12
14	″ ″ ″ ″ ″ ″ ″ R13
15	″ ″ ″ ″ ″ ″ ″ ″ R14
15½	L11-L12-B1-L21-RB1-RB2-L31-B2-L41-L42
16	L11-L12-M1-M2-L21-RB1-RB2-L31-M3-M4-L41-L42
17	Same plus-R11-R21-R31-R41
18	″ ″ ″ ″ ″ ″ R12-R22-R32-R42
19	″ ″ ″ ″ ″ ″ ″ ″ ″ ″ ″ ″ R13-R23-R33-R43
20	″ ″ ″ ″ ″ ″ ″ ″ ″ ″ ″ ″ ″ ″ ″ R14-R24-R34-R44

Fig. 22. Motor Circuits of General Electric High-Speed Locomotive

contactor R4 lifts, so that the RR4 contactor is the last energized. This gives five steps series and four parallel, the same as the automatic control of Figure 6. The rate of acceleration and the current fluctuations with this hand control are entirely governed by the judgment of the operator. An experienced man can, with uniform conditions of track and load, keep fairly well within moderate current fluctuations; but it is practically impossible in service to approach the accuracy and uniformity of the automatic control. When such accuracy is not particularly desirable, the hand form naturally commends itself on account of its simplicity.

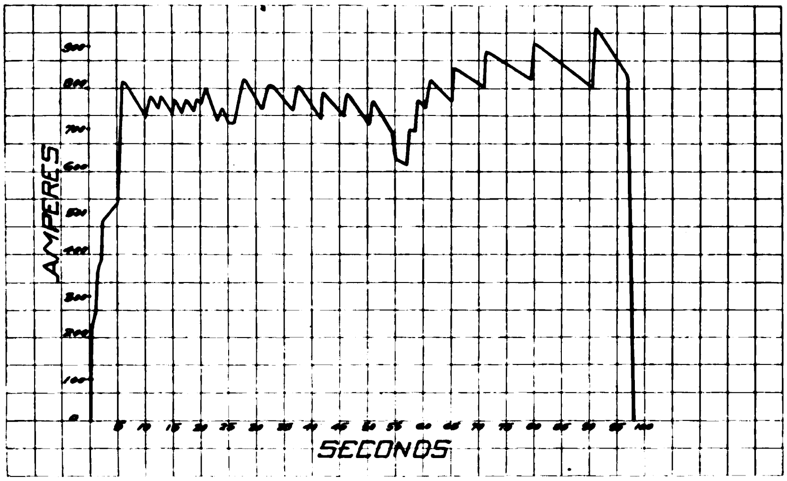


Fig 23. Current Record of Acceleration of High-Speed Locomotive

It is obvious that if the master controller of this hand control were turned on from step to step, under the restraining influence of the motor current, the control would become automatic in its action. Such an arrangement is used in a number of installations. The handle of the master controller, shown in Figure 20, is connected to the cylinder through the intermediary of a spring, so that when the handle is turned forward the spring is wound up and moves the cylinder forward under the influence of an electro-magnetic governor. A relay, Figure 21, with its coil in the motor circuit, is provided on each equipment. The contacts of these relays are connected through a train line wire with the coil of this governor, so that when the relay is energized by the increased motor current, at each step the governor locks the master controller cylinder. When the current drops sufficiently, it is released and the spring advances it to the next step, and so on.

Figure 22 shows the motor circuit of a high-speed locomotive with four motors Three connections of the motors are made, viz., four in series, two in series and two parallel, and four in parallel—each connection having a suitable number of resistance steps. The transfer between each connection of motors is made by the bridge method, so that the entire acceleration is made without opening the motor circuit. As in the two-motor control, separate sets of resistance are provided for each motor. In addition, two additional resistances at RB1 and RB2 are furnished to accomplish the bridge transfer from series to series parallel. In the first series connection, all the resistance sets of the four motors, except RB1 and RB2, are in circuit; on the second step the whole resistance set of the No. 2 motor is cut out; on the third step all of No. 4 set is cut out; and on the fourth step, all of No. 3 set is cut out. These first three steps are low-current or switching steps, three being provided to allow slow movements with the locomotive light, or with variable train weights. The accel·nection, the acceleration steps are produced by cutting out the steps of the No. 1 resistance set. In the series parallel connection the acceleration steps are produced by cutting out successively the steps of No. 1 set for Nos. 1 and 2 motors, and of

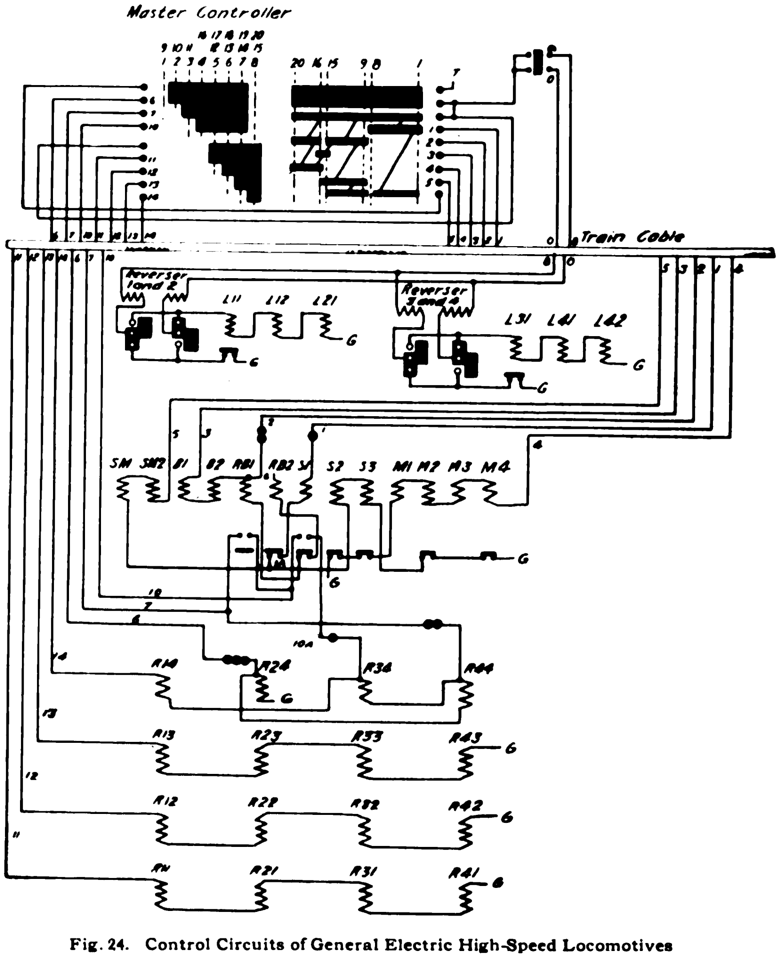

Master Controller
Train Cable
Reverser 1 and 2
Reverser 3 and 4
L11 L12 L21
L31 L41 L42
SM SM2 B1 B2 RB1 RB2 S1 S2 S3 M1 M2 M3 M4
R14 R24 R34 R44
R13 R23 R33 R43
R12 R22 R32 R42
R11 R21 R31 R41
G

Fig. 24. Control Circuits of General Electric High-Speed Locomotives

No. 3 set for Nos. 3 and 4 motors. In the parallel connection, the steps of each resistance set are successively cut out for the respective motors.

Although perhaps not obvious at first, it is found by analysis, using the method already described for two motors, that this arrangement of resistances is very nearly theoretically correct for the four-motor control.

When the resistance is all cut out in the series connection, the contacts SM1 and SM2 are closed, thus placing the motors in series parallel through the extra resistances. Contactors S1 and the R contactors are now opened, and RB1 and RB2 closed. When the resistances are again cut out, B1 and B2 are closed, and S2, S3 and the R contactors are opened and M1, M2, M3 and M4 closed, thus connecting the motors in parallel.

Figure 23 shows an acceleration current record on a locomotive with this control, and Figure 24 shows the control circuits.

The arrangement is in general similar to the hand control already described, and the master controller is provided with a governor and restraining relay which checks the advance of the cylinders when the motor current rises above a fixed value. The master controller, Figure 25, has two cylinders. The handle is attached to the one shown on the right, which is geared to the one shown on the left, so that the latter makes three revolutions to one of the former. The resistances are thus successively cut out in series while the first cylinder is moving from position 1 to 8, again in the series parallel position between positions 9 and 15, and a third time between positions 16 and 20. The connections are made directly from the master controller fingers to the contactor coils, which are arranged in circuits of four coils in series, or the equivalent, and may be readily traced on the diagram.

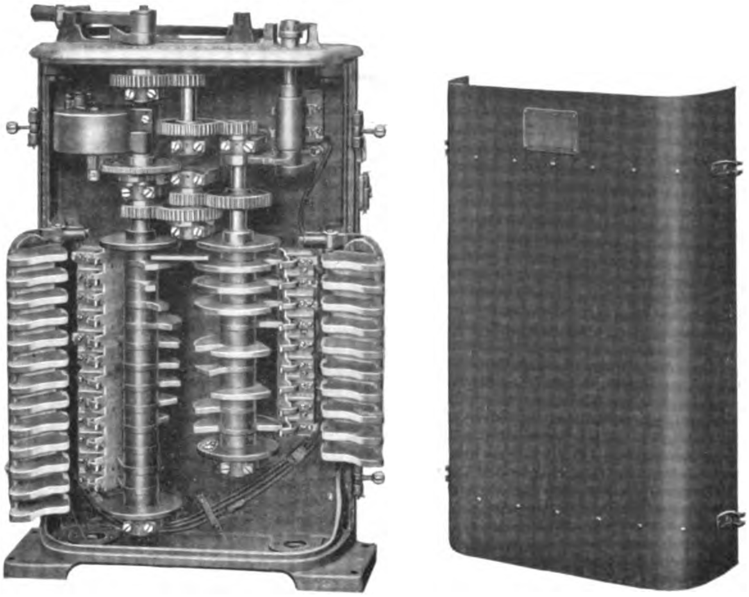


Fig. 25. Master Controller for High-Speed Locomotive Control

THERMAL PROBLEMS OF STATIC TRANSFORMERS

By W. S. MOODY

PART II

Early Steps in the Evolution of Artificially Cooled Transformers

The first *oil transformer* placed on the market in this country (about 1888) was the old Thomson-Houston, class B transformer. The purpose of using oil was primarily for insulation, and in advertising the transformer, great stress was laid on the merits of oil as a high grade insulation. The advantage claimed was that "break downs" between coils, and between coils and core, would immediately be reinsulated by the oil flowing in and around the damaged parts. This type of transformer was designed to operate with or without oil and was manufactured and sold in large quantities for several years before either the purchaser or builder appreciated that an increased output could be taken from the transformer when using oil. The class "B" transformers were, however, ahead of their time, as it was found that customers did not take kindly to the use of oil in transformers. The result was that the type E transformer was brought out using a sectional case and natural cooling, and it was not until the advent of the type F and G transformers that return was made to the use of oil. These types F and G were rated both with and without oil showing the growing appreciation of the fact that the use of oil increased the output for a given temperature rise.

The oil used with these earlier transformers was heavy and viscous, much resembling crude petroleum, and while perhaps the puncturing distance was higher than the lighter oil of those days, the heat conveying qualities were considerably less, owing to its sluggish flow.

The *paraffine filled* transformer was one of the unsuccessful steps in the evolution of the large transformer and is mentioned principally to show some of the financial set backs, as they may be called, to early manufacturers. This type was filled with paraffine instead of oil. The advantages claimed for the paraffine, before it was thoroughly tried out by the engineer who introduced it, were that at ordinary temperatures it was in a solid or frozen state, so that it would be possible to fill the transformer with melted paraffine and allow it to solidify, thus permitted it to be handled as a dry transformer in shipping; and when placed in service the paraffine would melt, and it would then have all the cooling and insulating qualities of an oil transformer.

The cooling quality of oil lies in its ability to convey the heat from the points of generation to the points of dissipation. It is in fact, a poor conductor of heat and in its frozen state it is an insulator of heat This is also true of paraffine, but to a greater extent.

After a short, but apparently successful, test on transformers filled with paraffine, but installed inside the building where they were made, a great number of transformers were built and sold. Fortunately, however, the first few were installed in the city in which they were made, as they immediately burned out. In a very short time every transformer manufactured had failed. This experience occurred in winter when conditions were most unfavorable to paraffine, as the paraffine adjacent to the exposed surfaces of the case could not readily melt, and in consequence, practically all the heat was confined within the sources of generation and rapidly caused the failures.

One of the early transformers cooled by water was the "water jacket" transformer. This was introduced in the latter part of 1895 by the Wagner Electric Manufacturing Company. In operation these transformers could be classed with the present water cooled type, the difference being in the method in which the water was circulated. Instead of separate cooling coils immersed in the oil, water cooling ducts were cast into the sides of the containing tanks. The ducts were approximately 1½ in. wide, vertically disposed and extending around the entire tank surface. This construction was extremely expensive and was soon abandoned.

As previously stated, a greater capacity may be taken from a transformer if it is immersed in oil than when operating dry.

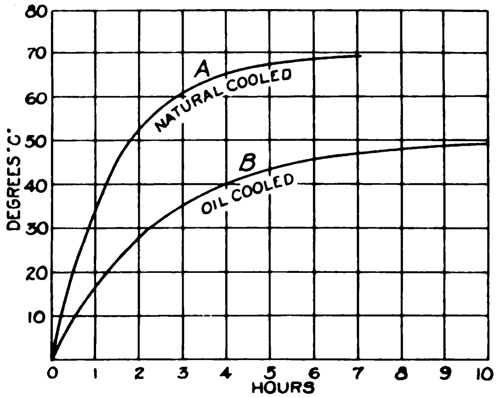


Fig. 5. Temperature Curves of Natural Cooled and of Oil Cooled Transformers

Figure 5 gives a typical form of temperature curve of a moderate size transformer, (7.5 kw.). Curve A shows approximately the rate of heating of the transformer when cooled by natural draft air, and placed so that it will have free circulation. Curve B is the same transformer immersed in oil. It will be noted that the temperature rise is considerably less when operating in oil than when operating dry. If the same temperature rises were allowed for the oil cooled transformer that was attained by the natural cooled, it will be seen that the capacity could be considerably increased.

Figure 6 shows comparative size of two 25 kw., 2000 volt, 60 cycle transformers; one, natural cooled, and the other oil cooled. Both transformers are designed to have the same temperature rise on corresponding loads. The weight of the natural cooled transformer is greater than the oil cooled. Its efficiency is the same at all loads. Other comparisons are as follows:

	Losses			Weight		Temp.
	Iron	Copper	Eff.	Iron	Copper	Rise
Nat. cooled	350	215	98	650	250	50°C
Oil cooled	350	215	98	277	145	50°C

Prominent Successive Heat Dissipating Inventions

Progress in large units began to be rapid only when it was appreciated that the space apparently wasted in cooling ducts was actually economical practice, and that a large unit with such space sacrificed was considerably cheaper than a number of small units aggregating the same total capacity, or one large unit with reduced density which depended only on its external surface for cooling.

A number of interesting heat dissipating patents were taken out in rapid succession which shows at once that considerable study was given the thermal problem. Some of the more prominent of these inventions are given below.

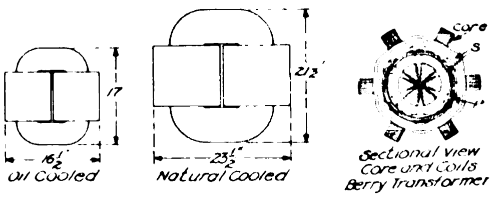


Fig. 6. Comparative Sizes of Different Transformers

Fluted or Corrugated Tank,—Patented 1890. Covered various forms of cooling surfaces for oil immersed transformers.

Cooling Subway Transformer,—Patented 1893. Gives a very unique method for cooling transformers installed in underground compartments where there is little or no air circulation to carry away the heat. The method consists in conveying the hot oil to a reservoir enveloping the water mains in the street where it was cooled. This method of cooling, however, required very close operation between the private lighting company and public water company, and naturally this co-operation could not readily be secured except when both the lighting and water companies were municipal. The method was, therefore, never used.

Cooling by Forced Air or Oil,—Patented 1894. This method consisted in mechanically forcing air or oil through apparatus to be cooled. Where oil was used it was pumped into a cooling reservoir, the hot oil leaving the tank at the top and cold oil entering it at the bottom. When air was used a blower furnished the cooling air, which entered the transformer at the bottom and exhausted at the top.

Cooling Hermetically Sealed Transformer Coils,—Patented 1894. This invention relates to cooling high tension coils which were hermetically sealed in metallic casing. Attention is called to this patent particularly because the feature of the invention was that the output of the transformers governed the rate of cooling. The greater the power delivered by the transformer the higher the speed of the motor operating the pump or blower. It was later found, however, that mechanical cooling was so efficient and required such a small percentage of the output of the transformer that this was an unnecessary refinement, and artificially cooled transformers as built to-day use the same amount of power for cooling at all loads, this amount ranging from .1 per cent to 1. per cent total output. The core and coils are built on a base having separate inner and outer chambers, the core forming the casing for the coils. Cooling is effected by forcing the oil up through the coils and allowing it to trickle down the sides of the core. The oil circulation is maintained by a motor driven pump, which lifts the oil from a reservoir below the transformer, then through a cooler to another reservoir located above the transformer, from which it flows by gravity to the transformer to be cooled. This was probably the first forced oil transformer.

Air Blast Transformer—Patented 1897. This design involved cooling by forced air draft and employed the principle of separate air circulation for the copper and iron, thus permitting a solid wall of insulation between the copper and iron. In previous forms the air had passed, first through the iron, then through the copper and back through the iron so that a solid wall of insulation between the core and winding was not possible.

Water Cooling Transformers—Patented 1900. This invention relates to cooling transformers designed for large currents, the feature being that of employing a hollow conductor for heavy current coils and circulating the cooling water through them.

Water Cooling Transformers,—Patented 1901. This patent covers improvements for circulating cooling water between the windings of the transformer and also through the oil above the transformer coils, by means of cooling coils. The cooling coils which are located in the windings are of rectangular section and are so disposed that the electro motive forces generated in them would result in a flow of current, but they are so connected that the e.m.f. of one set opposes that of the other so that energy losses and grounds are avoided.

Cooling Mediums

The *Cooling Mediums* now employed for artificially cooled transformers are oil, air, and water, and the choice of these mediums is usually governed by local conditions. The cost of energy consumed in artificial cooling is practically the same for all mediums, though there is some difference in cost of equipment. The cost of cooling, or power consumed, is but a fraction of the total output to be cooled, being less per kw. for a large installation than for a small, ranging approximately between .1 to 1. per cent of total output in existing installations.

Cooling Features of Modern Transformers

The dissipation of heat is effected in three different ways, by conduction, convection and radiation, and special methods have been devised whereby all these various elements are employed in cooling transformers to the best advantage.

The various types of modern transformers are the natural outcome of the thermal problem and all are designed with the idea of using some one or more of the above mentioned cooling elements. There are five different types; the natural cooled, oil cooled, air blast, water cooled and forced oil, and a sixth which is mentioned only as a possible future development, viz., refrigerated. This latter type has been considered, but no definite results have been attained.

In the *natural cooled* transformers the cooling takes place first by conduction to the surfaces of the coil where the heat is carried away by radiation and conduction, through the core to the case.

In order to augment the conduction from the points of generation to the points of dissipation, this type of natural draft transformer is generally impregnated with a compound which also serves as insulation. The transformers are designed to have the greatest possible external cooling surfaces.

In this country the manufacture of natural cooled transformers in sizes exceeding 5 kw. is practically extinct.

Natural cooled transformers are largely used in Europe due to the general practice of installing them inside buildings and other protected places. They are in general built without case. The Berry transformer is perhaps the highest type of this form now built and it embodies many good qualities of both the core and shell type transformer. The general form is shown in Figure 6. This transformer is regularly manufactured in sizes as high as 100 kw., and in a few special cases 150 and 200 kw. sizes. The temperature rise, however, is somewhat higher than allowed in this country, being from 55° to 65°. The active material of the 50 kw. Berry transformer weighs approximately the same as the 100 kw. General Electric oil cooled transformer of the same voltage and frequency.

The core type transformer gives perhaps the greatest effective cooling surface and if the operating characteristics and efficiency were not a consideration, much larger commercial sizes of natural cooled transformers might be made with this construction. This is in a great measure also true of the shell type transformer. Considerable departure can be made from the most efficient proportions with an increase in cooling surface more rapid than the increase in losses. The constant current transformer offers a good example of this in that the most efficient form is departed from in order to get high reactance between the coils for regulation. This naturally gives large cooling surface and it has been possible to build a constant current transformer in the natural cooled type much more cheaply than in the oil cooled type.

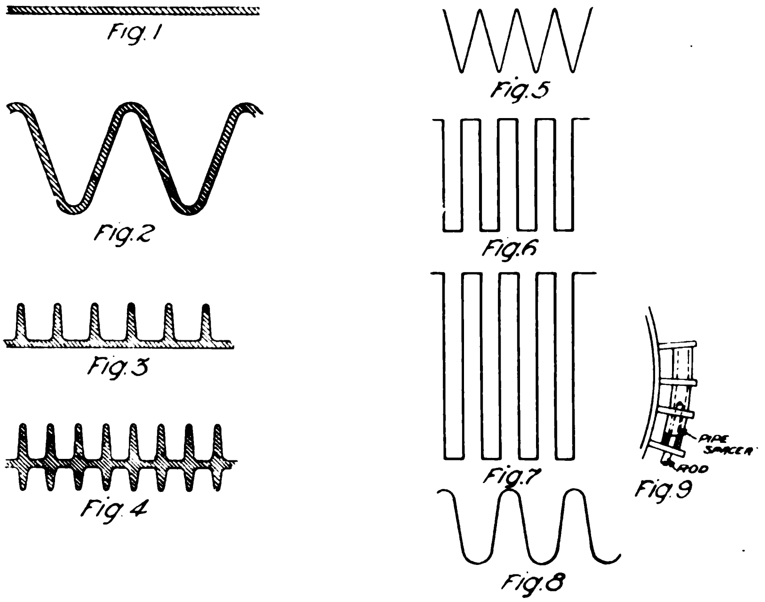


Fig. 7. Transformer Casings

The heat generated in *Oil Cooled* transformers is carried by conduction through the insulation surrounding the working material to the oil, then mainly by convection through the oil to the casing where it is dissipated by radiation and convection.

The cooling feature of this type of transformer lies mainly in the various forms of tank surfaces which are generally designed with a view of obtaining the greatest cooling area in the least possible space. Figure 7 shows the various modern forms of tank surfaces.

These cooling surfaces may be divided into two general classes,—plain and corrguated. Both classes are manufactured in cast iron, boiler steel and sheet metal; the cast iron varying in thickness from ½ in. to 5/16 in.; boiler steel from ⅝ in. to 3/16 in., and sheet metal from 3/32 in. to 1/32 in.

The sheet metal tank is most efficient and also the most difficult to build.

Perhaps the only obstacle, mechanically speaking, presented by the thermal problem is that of building perfectly oil tight sheet metal tanks, because oil is the most difficult of all fluids to hold. It creeps and spreads and will leak through the most minute pores where other fluids could not possibly flow.

The first of this type of tank was built about ten years ago, and even yet perhaps, with the exception of the General Electric Company, this problem has not been satisfactorily solved by other transformer manufacturers of this country.

The *Air Blast* transformer is designed to be cooled by air, hence every part of its working material is disposed so that every portion of it is at practically the same temperature. The cooling takes place similarly to the natural draft transformer except that it is carried away by forced instead of natural draft. In the modern type the air enters at the base and is divided into two paths, one circulating through the core and the other through the coils. Separate dampers are arranged for governing the cooling air whereby it is possible to vary the temperature rise to either coils or core. In the present form the coils are in the vertical plane and the laminations in the horizontal.

The *original air blast* transformers had their coils in the horizontal plane and the air passed,—first, through the core and through the coils, and through the core again—and finally through the other half of the windings and the remainder of the core. The result of this arrangement was that the ducts in the iron and the ducts between the coils were at right angles to each other, and the air shot across the surface of the coils in little jets which were far from being as efficient as the present method.

The cooling of the *Water Cooled* transformer takes place in the same way as in the oil cooled, except that most of the heat is conveyed to the cooling coils, through which water at considerably lower temperature is circulated and there it is carried away by convection. Some of the heat is dissipated by the containing tank. Two general forms of cooling coils are employed:

(a) Where the turns of each set of coils are in series and all sets in series.

(b) Where the turns of each set of coils are in series and all sets in parallel.

Each method has its advantages.

The *Forced Oil* transformer is an embodiment of the oil cooled, air blast and water cooled types, in that the working part is constructed in the same way as the air blast, while the cooling medium adjacent to the coils is oil and the cooling of the oil is affected by water. In general, the outside appearance of this type of transformer is the same as the water cooled. The cooling takes place in the same way as the oil cooled except that the oil is forced under pressure through the windings and core, entering the tank at the bottom and flowing out at top. The oil, after it leaves the transformer enters the cooler, in which it is cooled by means of water or air.

The growth in size of the large transformer units since the thermal problem was actively considered has been something remarkable. The steps in progress are as follows:

1893,	50 kw.
1894,	100 kw.
1897,	880 kw.
1899,	1875 kw.
1900,	2250 kw.
1902,	2500 kw.
1903,	2750 kw.
1904,	3000 kw.
1906,	7500 kw.

The design and manufacture of modern transformers is undertaken with the same confidence as the building of a large steam engine or generator and the subsequent operating performance is predicted from the design with perhaps a greater degree of accuracy than is common in even so old and stable an art as that of engine building.

The prediction of the future transformer is that it will be built in even larger units.

MINING LOCOMOTIVES.

By W. E. BROWN

The condition of the locomotive business is to-day more prosperous than at any previous time in the history of the company. At present there are ninety-five electric mine locomotives on order, which orders have been received principally from the Philadelphia, Chicago, and Denver districts. Among prominent purchasers are the D. L. & W. R. R., the N. C. Frick Coke Co. of Pittsburg, Pa., the New River & Pocahontas Coal Company, West Virginia, and the Hillside Coal & Iron Company, the Erie R. R. Company, and the Pennsylvania Coal Company of Scranton.

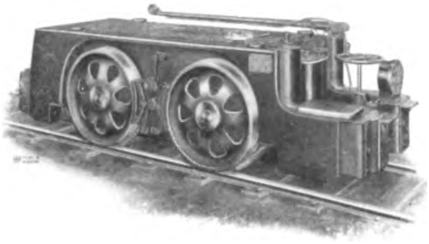


Fig. 1. Eight Ton Outside Wheel Locomotive

The receipt of large orders for locomotives from customers who have been users of General Electric Company's apparatus for long periods of time, and who have also experimented with locomotives manufactured by competitors, but who have returned to the former with new and larger orders, indorses the confidence which we have always had in this company's machines.

During the past year an 8-ton, outside wheel type of locomotive has been developed, which is shown in Fig. 1, and the Company is now in a position to furnish an outside wheel type of locomotive of sizes from the 3-ton to the 10-ton inclusive.

The most radical departure made during the past year in the manufacture of mine locomotives, was the development of a three-motor machine, which is shown in Fig. 2. This locomotive was equipped with three GE-61 motors for operating on a 24 in. gauge, in the mines of the Pittsburg Coal Company. The reports received on its operation in actual practice have been most satisfactory, and the customer expresses himself as greatly pleased with this machine.

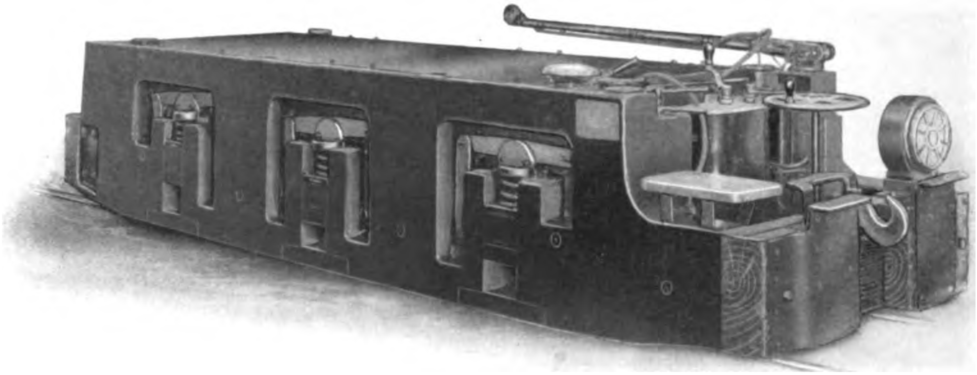


Fig. 2. Fifteen Ton Locomotive

The success of the operation of this locomotive depends primarily upon the method used to equalize the weight on all three axles. To accomplish this, the regular standard axle springs with equalizers made of bar steel have been used, the cap on top of the spring serving as a guide and support for the equalizers, which are placed in the center and on top of each journal box. The front and rear wheels on this locomotive are provided with flanges, while the center wheels have no flanges, thus allowing the locomotive to freely round a 45 ft. curve. The brake is of the regular steam locomotive design, and the pressure of the brake shoes is perfectly equalized on each of the six respective drivers. The controller provides for operating all three motors either in series or in multiple.

There has also been developed, for use with the LM-105 locomotive, a split frame motor which will mount in a minimum gauge of 18 in. and which has been designed to supersede the NWP-2½ and CB-15 motors.

For use on the LM-103 locomotives a split frame type of motor has been designed that will rate approximately 20 per cent more than the CB-14 type of motor, which it is intended to supersede.

Both of these new types of motors are constructed with form wound armature coils, the motors which they are designed to replace being of the Gramme ring type.

A 14 ton locomotive equipped with the GE-97 motor has also been listed for orders. This motor is approximately 20 per cent higher in horse power rating than the GE-53 type of machine, which heretofore has been the most popular for use on locomotives of approximately this rating. In design, it is of the frame split type, oil lubricated, and with very liberal bearing surface—in fact, this is an attempt to produce a motor which will most successfully stand up under the severe usages to which this particular type of locomotive is subjected.

This we believe is the most complete line of mining locomotives offered by any manufacturer in the market, and with the addition of the new types of motors referred to, is superior in every respect to that of any other make.

A. I. E. E. BRANCH NOTES.

The first meeting of the month was held on April 4th and was devoted to the subject of Lightning Arresters, Messrs. Steinmetz, Rushmore, Creighton and DuBois presenting abstracts from their recent papers read at the meeting of the Institute on March 29th in New York. The recent developments in lightning arresters have been epoch making, and as each of the speakers has devoted much time to the subject and is an expert therein, the meeting was of exceptional interest.

Dr. Steinmetz's talk covered the general phenomena of static disturbances, and the conditions arising therefrom which must be met in arrester design. The succeeding speakers then discussed the later devices for safe guarding against these phenomena. Mr. Rushmore described the new multigap arrester and Mr. Creighton the liquid electrode type. Mr. DuBois showed many interesting and valuable slides.

April 11th had been reserved for a paper by Mr. G. H. Hill of the Railway Engineering Dept., on Multiple Unit Control for D. C. motors, but owing to the death of Gen. Eugene Griffin, no meeting was held and the reading of the paper was postponed until April 18th, at which time Mr. Hill lectured to an exceptionally large audience, giving the history and development of this method of control and describing very fully the present system in use. The April Review contained the first part of Mr. Hill's paper—the second and last portion appears on another page of this issue.

At the meeting of April 25th, Mr. C. H. Hill presided, and Mr. Ernst J. Berg read a paper upon "Constants of Cables and Magnetic Conductors" (which will be found in the April issue of the Review. Mr. Berg also discussed the skin effect in solid and stranded cables with metallic covering. In addition he devoted some time to the subject of algebra of complex quantities. The possible dangers resulting from the grounding of one side of a large tension transmission line on a telephone circuit attached to the same poles were also discussed, and Mr. Berg said that special precaution should be taken to properly protect the telephone switchboard operators, when the conditions are such as to make an occurrence of this kind possible.

NOTES.

Mr. E. W. Rice, who has been travelling in California, returned to Schenectady on April 25th. Mr. J. R. Lovejoy, who was with Mr. Rice on the Coast, returned several days previously.

* * *

Mr. Robert D. Mure of the Lighting Department, was married on April 3rd to Miss Ellette C. Tenney of Washington, D. C. Mr. and Mrs. Mure will reside at 141 Park Ave., Schenectady.

* * *

Mr. John Paris Palmer, who has recently been transferred from the "Test" to Mr. Haskins' Department, was married on April 2nd to Miss Lata Crawford Jones of Quantico, Md. They will make their home at 122 Brandywine Ave., Schenectady.

* * *

Mr. H. E. Duren of the Power & Mining Department, has left for San Francisco, where he will devote himself to transmission works.

* * *

The New General Electric Plant at Erie

The development of electrical industries, and especially the rapid growth of the General Electric Co. business, which is continually demanding a greater output, have necessitated increased manufacturing facilities, and to this end the Company has arranged for the construction of a new plant.

This plant will be located to the East of the City of Erie, Pa., where 700 acres of land, extending from the Lake Shore Railroad to the lake front, have been purchased.

The Company intends to devote about two-thirds of this land for building sites for their employees.

It is not the intention of the Company to discontinue any of the present plants, the new one being established merely to meet the increasing demands of trade.

* * *

We have had the pleasure of a visit from Dr. Eichberg of the Allgemeine Elektricitats Gesellshaft of Berlin. Dr. Eichberg is well known as the inventor of the Winter-Eichberg Compensator Repulsion Single Phase Motor, which has been applied with great success in a number of European railroads. Dr. Eichberg came to this country as a delegate at the dedication of the Engineering Societies Building and will remain for some weeks.

* * *

At the annual meeting of the National Association of Cotton Manufacturers held at the Mass. Institute of Technology, Boston, Mass., April 24th, 1907, Mr. Charles B. Burleigh was awarded the association medal in recognition of a paper entitled "The Curtis Vertical Steam Turbine," presented by him before the Association Sept. 13th, 1906.

The presentation was made by Chairman Plunkett of the medal committee, who said:

> "In our judgment there has been during the past year nothing of record in the transactions of the association, nor in the nature of inventions which better deserves the distinction of highest place among the contributions to the science and business of cotton manufacturing than the consumately prepåred paper by Mr. Burleigh, read at the fall meeting at Hotel Champlain."

The following is the act adopted by the Association at its annual meeting in 1899 under which this medal was awarded:

> It is the purpose of the Board of Government that this medal may be given to any person whose work has been, in their opinion, an advantage of sufficient importance to the purposes to which this organization is devoted in its broadest sense, including any papers read before the Association.
>
> The reasons governing the award shall be entered on the records of the Board of Government, and the medal will be accompanied by a suitable diploma executed by the President and Secretary, setting forth the award and the cause for which it was made."

Description of Medal

The obverse bears the name of the Association and the dates of its foundation and incorporation.

In the middle is a loom of the pattern in general use at the time of the foundation of this Association, surrounded by a garland of cotton balls, those in the right being sea island cotton, and on the left, upland cotton.

The name of the Association in mural text is girted by a polygon of hanks of yarn knotted together.

The reverse of the medal bears a chaplet of oak and laurel leaves symbolizing strength and honor, and secured at the base by an American eagle with outstretched wings, the whole forming a frame of the tablet containing the inscription of the name of the recipient, and the cause of the award.

QUESTIONS

Questions Asked at the Chicago Agents Meeting

Q. 1. For what percentage increase in speed of generator or exciter will a Tirrill regulator compensate?

A. The Tirrill regulator is capable of handling a 100% increase of excitation, whether this is caused by speed changes or load changes. If, therefore, the variations in speed of the genrator or exciter do not call for a greater increase in excitation than 100%, the Tirrill regulator furnishes satisfactory compensation for the speed changes.

Q. 2. Can Tirrill regulators be used to control the voltage of two generators operated in multiple, but located in different stations?

A. Tirrill regulators can be used to control the voltage of two different generators operating in multiple and located in different stations, but such operation is not usually considered practicable, as rather delicate adjustments are necessary. Up to the present time, the recommendations have been that only one Tirrill regulator be used, and that it be located in the receiving end of the station, or where the second generator is parelleled with the first.

The regulator, so installed, will handle any fluctuations in voltage and also compensate for line drop from the second station to the centre of distribution.

Q. 3. What is the limit of the number of exciters which can be controlled from one Tirrill regulator?

A. The number of exciters which the Tirrill regulator can control depends largely upon the capacity and characteristics of the exciter. For illustration: it is expected that the new form F-12 regulator could be made to contral twelve small exciters, or it is believed that the same regulator can be used on any number of exciters up to twelve, by using different groups of relays, with the resistance of the exciter field rheostat divided into different sections, depending upon the sizes and characteristics of the exciters: that is, provided the capacity of the regulator is not exceeded. It does not often occur, however, that more than three or four exciters are located in one station.

Questions Asked at the Atlanta Agents Meeting

Q. 1. How should we distinguish in our recommendations between Tirrill and feeder regulators; where should both be recommended?

A. The Tirrill regulator can be adjusted to compensate for predetermined voltage at the bus bars, or at the centre of distribution of the given feeders. It cannot be adjusted to maintain and compensate voltage at the centres of distribution of a number of feeders if the compensations demanded by the different feeders vary.

Feeder regulators, on the other hand, can be placed on all of the feeders, and work independently to meet the demands of the particular feeder on which each is installed. Often when feeder regulators are installed, however, the Tirrill regulator forms a valuable adjunct to the station equipment, and can be made to afford an economy in the station equipment in two ways.

First: The Tirrill regulator may have its compensation devices placed in one of the feeders, thus precluding the necessity of a feeder regulator in that particular feeder.

Second: The Tirrill regulator can be adjusted to furnish a given amount of compensation required by all the feeders, thus permitting the use of feeder regulators of smaller capacity than would otherwise be required.

For illustration: if all of the feeders required simultaneously 5% compensation, and not simultaneously 10% the Tirrill regulator could be installed and adjusted to furnish the 5% compensation and the feeder regulators the additional 5%, where otherwise the feeder regulators furnishing 10% compensation would be required.

Third: A heavily loaded feeder carrying a motor load, or other inductive load which would tend to disturb the voltage of the generator, and therefore the entire system; would demand the use of a Tirrill regulator on the generator in addition to the feeder regulators on the individual feeders, as the most ideal arrangement.

These are only a few of the cases where the conditions warrant the operation of the two devices jointly and many conditions arise in actual practice where it is advisable to install both types of regulators.

ABSTRACTS OF IMPORTANT TECHNICAL ARTICLES

* Illustrated

The Strauss Trunnion Bascule Bridge Near Rahway, N. J.

[The Engineering Record, April 13, 1907, p. 465*]

The bridge being built for the New Jersey Short Line Railroad (a double track interurban line now under construction between Philadelphia and New York) crosses the Rahway River at a point about four miles below Rahway, N. J. It will have a single moving leaf and a clear span of 65 ft. The operating machinery will be gear driven by two 15 h.p. General Electric motors, which are to be controlled by means of controllers and switch-board located in the operator's house. The operating speed contracted for amounts to 1.25 minutes for the leaf movement, and the power required is about 20 Amp., at 450 volts.

THE WASHINGTON NAVAL GUN FACTORY

Miscellaneous Points of Interest in the Navy Yard New Electrical Generating Plant, Museum, Propeller-planing Machine, Etc.

[American Machinist, March 28, 1907, p. 446]

One of the latest improvements in the Navy Yard is the new power station supplying electric current for power and lighting.

It is equipped with four 500 kw., 120 r.p.m., 240 volt engine driven General Electric D. C. generators.

New 14-Ton Motor Cars, Denver City Tramway

[Electric Railway Review, April 6, 1907, p. 452]

In addition to their standard 4-motors cars, the Denver City Tramway have recently put in service on their line 30 new 14-ton motor cars with a two motor GE No. 53 (50 h.p.) equipment. The cars have a seating capacity for 48 passengers, and are designed with the view to obtaining extreme lightness without sacrificing a good factor of safety for any important structural members.

Some Construction and Operating Features of the Alton, Granite & St. Louis Railway

[The Street Railway Journal, March 30, 1907, p. 531*]

This road operates between East St. Louis, Alton and Edwardsville, Ill., including 34 miles of track.

Electric power is obtained from the power station of the East St. Louis and Suburban Co., and is transmitted at 13200 volts to two sub-stations, one equipped with two 400 kw., and the other with two 300 kw. General Electric rotary converters. The rolling stock consists of eight interurban cars equipped with G. E. 73 motors, and Sprague G. E. Multiple unit system of control.

Electrically Driven Paper Mill in Japan

[Western Electrician, April 13, 1907, p. 323]

The Oji Paper Company of Tokio, Japan.

This paper mill is situated at Hokaido and consists of a hydro-electric power station with four 3125 KVA., 60 cycle 3450 volt water wheel driven, three-phase G. E. alternators.

One 150 kw. water wheel driven, and one 150 kw. induction motor driven exciter.

Twelve 1050 kw., 3450-44000/45000/46000 volt step-up transformers.

A transmission line of over 15 miles runs to sub-station with 12 step-down transformers, 2100/2200 volts.

The mill is equipped with five 750 h.p., 2000 volt induction motors for pulp grinder drive.

Four 350 h.p., 2000 volt induction motors for beater drive. (Rope transmission).

And one 200 h.p. induction motor for beater drive. (Rope transmission).

Elgin-Belvidere Electric Railway

[Western Electrician, April 13, 1907, p. 319]

This thirty miles interurban road in Northern Illinois, connects with the Aurora, Elgin and Chicago Railway, the well known high speed third-rail line. Electric current for its operation is obtained from the Batavia Power House of the latter road and is supplied to three sub-stations located along the line. These are equipped with 300 kw., 25 cycle G. E. rotary converters and necessary appliances.

The passenger cars have a four motor (74 h.p.) equipment.

The Shawnee-Tecumseh Traction Company

[Street Railway Journal, April 13, 1907, p. 637]

The City of Shawnee, which has a population of 22,000, is connected with Tecumseh by means of a five mile interurban line, operated by the Shawnee-Tecumseh Traction Co., which also controls 6.5 miles of trackage in the City of Shawnee.

The power is rented from the Shawnee Lighting Co., and converted into direct current by a 300 k.w. General Electric Motor Generator set.

The rolling stock includes 15 interurban cars, which are equipped with four GE 80 Motors, and K 28 B Controllers.

Dominion of Canada

[Western Electrician, April 13, 1907, p. 330]

The Canadian General Electric Company's net earnings for the last year were $853,675, or fully 18 per cent. on the capital, as compared with 16 per cent. for 1905.

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